POWER

Vol. 34 NEW YORK, SEPTEMBER 19, 1911 No. 12

FROM the foretruck of the battleship "Michigan" there flutters in the breeze a silken pennant, in the center of which is a big black ball, signifying that this big war-machine is the champion of the American navy in battle efficiency.

It took twelve months' hard work for 850 men to win that emblem. "Every officer and every man," said the commander, "had a part in winning this pennant, and when I was ordered to designate a few men whose work was most conspicuous, it was an almost impossible task."

For a whole year the "Michigan's" record for engineering competition and gunnery practice reached the wonderful average of 94 per cent.

We have often wished that the word efficiency could be reduced to a plain, one-syllable word. We have words in our working vocabulary which are shorter and, if not sweeter, are more to the point. If this were done, perhaps a fuller realization of the importance of "efficiency" might be had and its proper use made more common.

It means skill and industry; and its attainment means a thorough knowledge of one's vocation and the necessary energy to put that "knowing how" into effect.

It was not merely for the privilege of flying that silken pennant at the foretruck of their "power plant" that 850 men worked unceasingly for a whole year. The pennant is but a symbol, a sign of what skill and industry —efficiency—can accomplish if properly directed and applied.

No illuminated sign is needed to blaze forth the efficiency of a well conducted power plant; its efficiency is concealed in the engine room, in the boiler room, in the office—but it is there, "below decks!"

"Every officer and every man" contributed by his labor to the efficiency of the big battleship. What an illustration is served for our field of work in this quotation! It means that the coal-passer (the fireman) knew his business; that the oiler was on the alert; that the engineer had his "finger on the pulse" of the machinery; that the navigator (the operating engineer) steered the "straight course"; that the commander (the chief engineer) felt himself personally responsible for even the most insignificant post of duty and so delegated his authority and mapped out the duties of 850 men that each man was a $\frac{1}{850}$ of that wonderful record of efficiency.

It is hardly necessary to state that there is no joyous tooting of whistles, no loud huzzas from the excited populace, no extravagant encomiums from the daily press when the power-plant force does its duty.

We cannot adopt navy methods of declaring our efficiency, but we can strive to increase its average, and this will be a declaration that will certainly help to fatten the pay envelop.

Priming of Water-Tube Boilers

By T. F. Maguire

The fundamentals of a proper circulating system; the circulation in several well known types of water-tube boilers, and the influence of steam space, water space, liberating surface and water level.

A boiler is said to prime when the steam leaving it carries a certain amount of water in suspension. All water-tube boilers will deliver steam containing moisture, unless equipped with superheating apparatus, but usually this moisture is not great enough to seriously affect the operating economy or the safety of the plant. When priming, however, the water carried over by the steam is in excessive quantities and not only greatly impairs the plant efficiency but if in large bulk endangers life and property. A certain type of boiler might give entire satisfaction in one plant and be a complete failure in another on account of its tendency to prime under the operating conditions of the second plant.

A purchaser of water-tube boilers will usually give careful consideration to such points as the heating surface, the ultimate strength of the various parts, the grate area, the stack dimensions, etc., but seldom gives thought to the features of the boiler that determine its ability to operate successfully without priming.

The size of a boiler is determined from the load it will have to carry, but the type and design of a water-tube boiler for a successful installation must be determined from the plant conditions, such as the quality of the feed water, the maximum load and its duration, the rate at which the load may vary, etc. Certain feed waters contain impurities that will cause any water-tube boiler to prime if they are allowed to reach a sufficient concentration, and no two boilers will prime at the same degree of concentration.

Priming may manifest itself as a heavy continuous discharge of water with the steam or by intermittent discharges of slugs of water separated by intervals of comparatively dry steam. The latter condition is particularly vicious, as the slugs are likely to wreck the piping and the engines before the trouble can be remedied. In the case of the continuous discharge of water, the operating force has usually sufficient warning to cut the apparatus out of service before any serious damage occurs.

The particular points in the design of any boiler which should be considered with reference to its probable priming tendency are its circulating system, the total and effective liberating surfaces, the steam space acting in the capacity of a receiver and a separator, the water space up to the normal water line and the fluctuation in the water level at different rates of driving.

The results of investigations of these five factors are given in the following discussion. Certain types of boilers have been taken for illustration merely because they happen to be particularly well known or involve features that are of peculiar interest.

Circulating System

The necessity of providing for circulation may be appreciated from a consideration of the elementary boiler shown in Fig. 1, where *B C* represents a water tube, inclined to the horizontal and terminating at both ends in the vertical headers *A B* and *C D*. If the ends *A* and *D* are both open to the atmosphere, the surface pressures in the two headers are equal at all times, and if heat be applied to the exterior surface of the tube *B C*, steam will be generated and it will travel toward *B*, finally escaping at *A*. A certain amount of water will be carried along by the steam on its way through the tube, even up to the water surface in the header *A B*, and it is evident, therefore, for the simple arrangement here shown that a path must exist in the header *A B* and in the tube *B C* for the return of the water. When this elementary boiler is operating there are two distinct fluids circulating in *A B* and *C D* in opposite directions, one consisting of a mixture of steam and water, the other of water alone. With a low rate of driving this boiler would work in a fairly satisfactory manner as the two oppositely moving fluids would not greatly interfere. As the rate of steam generation increased, however, the tendency of the steam to pick up water would increase in even greater proportion, and the fluid velocities would rapidly increase, resulting in a marked interference between the two opposing currents. As the rate of driving was further increased the interference would finally cause the boiler to prime excessively or boil over.

An interesting point to consider in the operation of such an elementary boiler as that shown in Fig. 1 is the difference in water level that exists in the headers *A B* and *C D*. With the application of heat to *B C*, a certain amount of steam must exist in all parts of *B C* and up to the water level in the leg *A B*. For static equilibrium the pressure at the lowest point *C*, due to the weight of the steam and water in *A B C*, must be equal and opposite to the pressure due to the solid body of water in the leg *C D*, as the two pressures on the surfaces of the fluids in *A B* and *C D* are the same. It is a simple matter to show that the difference in water levels in the legs *A B* and *C D* depends upon the proportion of steam to the water in the length *A B C* and that the harder the boiler is driven, the greater will be the difference. This difference in the water level is present in certain commercial water-tube boilers, notably those of the cross-drum type, and is due to the varying proportions of the steam and water in certain parts of the boiler.

The boiler shown in Fig. 1 would not be a success commercially, as it would prime excessively on account of the two oppositely moving fluids in the same tubes or headers. To eliminate this effect a return circuit must be supplied from the front header *A B* to the rear header *C D*. This may be done by providing a horizontal connection at the top between the headers, as shown in Fig. 2. Here the steam leaves the water at *A* and the water carried up the leg *A B* is conveyed by the element *A D* back to the rear header *C D*, thus minimizing the countercurrent effect in *A B C*.

The horizontal section *A D* may be parallel to *B C* or inclined without affecting the circulation. Such an arrangement is shown in Fig. 3 and is well worth considering inasmuch as many well known water-tube boilers are designed in accordance with this fundamental arrangement.

The manner in which heat is applied to a boiler has an important bearing upon the circulation. In Fig. 2 the application of heat to the horizontal section *A D* would in itself cause no positive circulation in either direction. The application of heat to any part of the section *A B C* would produce a positive circulation in the direction *C—B*, while heat applied to the section *C D* would produce a circulation in the direction *B—C*. With a simultaneous application of heat to the entire circuit *A B C D*, the direction and velocity of the circulating fluid would depend upon the relative proportion of steam to water in the two sections *A B C* and *C D*. In Fig. 3 the application of heat to any part of *A B C* would cause a circulation in the direction *C—B* through the entire circuit, while an application of heat to *A D C* would cause a circulation in the reverse direction. If heat be simultaneously applied to the entire circuit *A B C D*, the direction of the circulation will depend upon the relative amounts of steam generated in *A B C* and *A D C*.

In Fig. 4 is shown an elementary boiler consisting of two inclined tubes and one horizontal tube, all three terminating in the two headers *A B* and *C E*. The application of heat to *A B C* would produce a circulation in the direction *C—B* in *A B C; A—D* in *A D* and *A—E* in *A E D;* while the application of heat to *A D* alone would cause a circulation, in *A D* in the direction *D—A*, in *A B C* in the direction *B—C* and in *A E D* in the direction *A—E*. With heat applied to the horizontal tube *A E* alone, the direction of circulation would be indefinite.

Types of Boilers—Babcock & Wilcox

The Babcock & Wilcox type consists of a nest of straight water tubes inclined 3 inches to the foot, the tubes being expanded at both ends into sectional headers, which in turn are connected by suitable nipples and cross boxes to one or more horizontal longitudinal drums. This boiler is usually provided with two vertical baffles by means of which the gases of combustion are compelled to travel three times across the nest of inclined tubes and approximately at right angles to them. The rate of steam generation differs greatly for the various parts of the heating surface. The bottom rows of tubes in the first pass do considerably more work than the top rows in the same pass, while the top rows in the second pass exceed the work of the bottom rows, the reverse being true for the third pass. But the difference in the rate of steam generation is far greater between the lowest and highest rows in the first pass than in the second pass, and for this reason the steam generated during any given time is greater in the bottom rows of tubes, considering the entire tube lengths, than in the top rows, the rate of steam generation for the intermediate rows varying according to their positions. This varying rate of steam generation is caused by the gases at the highest temperature impinging upon the lowest tubes in the first pass and also because the lengths of tubes enveloped by the gases decrease as the gases rise through the first pass on account of the decrease in the volume of the gases and their tendency to crowd toward the top of the baffles. If the furnace is placed directly under the first pass the radiant heat from the fuel bed will further increase this discrepancy.

Considering the circulation in this type of boiler, each front header discharges into the upper longitudinal drums through a single nipple, and there being but one nipple for each vertical row of tubes, which is of the same diameter as the water tubes, it follows that there is a decrease in the cross-section of the circulating path at the point where the nipples connect to the headers. In a boiler twelve rows high the cross-sectional area of the nipples would be but 8.5 per cent. of the total cross-section of the tubes. As the water level is carried on the center line of the upper drums there is a considerable head of water over the front and rear nipples and the circulation is usually assumed to be from the rear to the front in the inclined tubes, through the front headers and nipples into the overhead drums, back through the drums and down the rear nipples to the rear headers. If the flow is from the rear to the front in all of the inclined water tubes, then the entire discharge of each vertical row must pass through one nipple. Such a circulating system would conform to the simple boiler shown in Fig. 2. It is quite likely, however, that the circulation does not occur entirely in this manner.

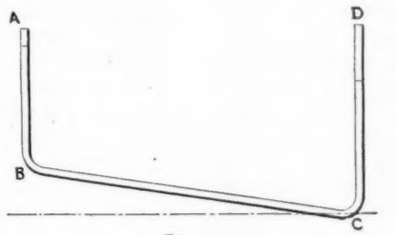


Fig. 1

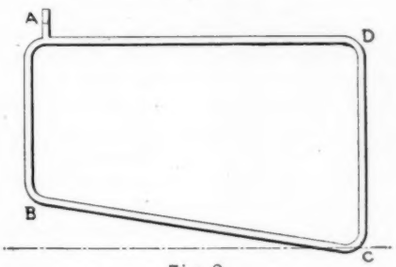


Fig. 2

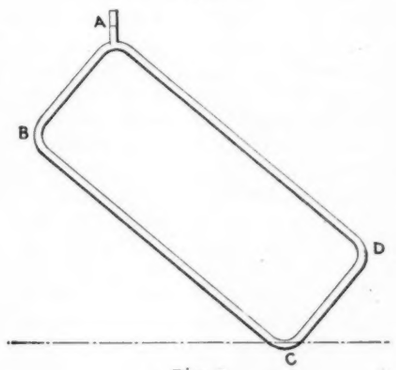


Fig. 3

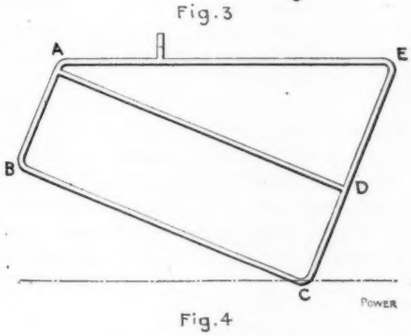


Fig. 4

Elementary Boilers

As there is much less steam generated in the top rows of tubes than in the bottom rows, there is less tendency for the contents of the top tubes to move from the rear to the front. Also, the relatively small areas of the front headers and nipples produce a throttling effect which creates a force in opposition to the flow from the rear to the front of the tubes, and this force is greatest at the top row of tubes.

For these reasons it is likely that part of the circulating water in a Babcock & Wilcox boiler flows, at certain loads, from the front to the rear headers through the upper rows of tubes. However, the steam generated in these upper rows flows to the front, causing a double flow in the tubes.

Heine Boiler

The Heine boiler consists of a nest of straight water tubes inclined to the horizontal at 1 inch to the foot, the tubes being expanded at both ends into the headers, extended and riveted to the overhead longitudinal drums. This type differs from the Babcock & Wilcox type in that the front and rear headers each consist of a single chamber instead of many sections and are formed of riveted steel plates suitably strengthened by staybolts. In addition the headers are riveted to the overhead drum or drums instead of being connected by nipples. In order to simplify the construction of this boiler and make the front and rear headers the same size, the longitudinal overhead drums are set with their axes parallel to the tubes, making the water level in the drum, when the boiler is not in service, much higher at the rear than at the front.

The method of baffling is different from that employed in the Babcock & Wilcox type. The baffles are of the so called horizontal type usually consisting of a tile baffle between the first and the second rows of tubes and extending from the front header to a point about 3 feet 6 inches from the face of the rear header, and an upper baffle resting upon the top row of tubes and extending from the rear header to a point about 3 feet from the face of the front header. With this arrangement the hot gases pass to the rear of the setting below the lower baffle and enter the nest of tubes through the opening between the end of the lower baffle and the rear header; they then pass along the tubes to the opening between the top baffle and the front header and finally travel under the drums to the rear of the setting where they escape to the breeching. As the tendency of the hot gases is to rise, it is probable that they hug the upper baffle and therefore the front section of the tubes, just above the lower baffle, is short-circuited. Obviously, the bottom row of tubes in this boiler does far more work in proportion to the other rows than the lowest

row of a boiler with vertical baffles, and inasmuch as the gases tend to hug the upper baffle the highest rows do more work proportionally to the remaining rows (excluding the lowest row) than do the highest rows in a boiler with vertical baffles. However, as the gases pass across the intermediate rows, it is probable that the relative amounts of work done decrease from the lowest to the highest rows, only the decrease between adjacent rows is not so marked as in the case of vertical baffles.

The area of the throat of the front header leading to the drum is far greater in a Heine boiler than in one of the Babcock & Wilcox type; hence, the throttling effect tending to oppose the flow into the drum is much less. The tendency of the contents of all the inclined tubes is to flow from the rear to the front, but owing to the relatively small amount of steam generated in the top row, it is quite likely (as in the Babcock & Wilcox type of boiler) that a certain amount of the water returns from the front to the rear header, through the upper rows, the steam generated in these return tubes flowing, however, to the front and creating a counterflow. As in the Babcock & Wilcox type, the direction of the circulating water in some of the tubes may change, depending upon the rate at which the boiler is driven. In boilers of the Heine type, in which the axes of the overhead drums are parallel to the inclined tubes, the steam outlets from the drums are at the front over the front header, a suitable baffle being placed over the discharge to prevent a direct path for the flow of the steam and entrained water into the steam piping.

Stirling Boiler

The Stirling water-tube boiler differs materially from the two previously mentioned types. It consists fundamentally of four drums extending across the setting, one drum located at the bottom and to the rear of the bridgewall, the remaining three drums being suspended on a suitable framework. One bank of tubes connects the bottom drum with the upper front drum, a second bank connects the bottom drum with the intermediate drum and a third bank connects the bottom drum with the upper rear drum. In addition to this there are a single row of short tubes beneath the water line connecting the upper front and intermediate drums, a single row of short tubes above the water line, connecting the upper intermediate and front drums, and a single row of short tubes above the water line connecting the intermediate and rear drums.

The baffles of the Stirling boiler are so arranged as to compel the hot gases to pass up the entire length of the tubes connecting the bottom and upper front drums; then down the entire length of the tubes connecting the bottom and upper intermediate drums; and finally up along the tubes connecting the bottom and upper rear drums, from which they escape to the breeching. As the heating surface of the front bank is at least equal to that in either of the other two banks, and as the gases impinge initially upon the front bank and travel along its entire length before coming in contact with any other heating surface, the steam generated in the front bank is much greater than that generated by the remaining heating surface of the boiler. The heating surface in the intermediate bank does considerably more work than that of the rear bank, but the greatest consecutive difference exists between the front and intermediate banks. The real circulating system of this boiler consists of the bottom drum, the front bank of tubes, the upper front drum, the short water tubes connecting the upper front and intermediate drums and the intermediate bank of tubes; the rear upper drum and the rear bank of tubes do not constitute a part of the circulating system, but more nearly resemble a feedwater heater.

The inclination of the tubes connecting the bottom and the three upper drums being great, there is a tendency for the contents of all the tubes to flow from the bottom to the top, discharging into the upper drums. As the rate of steam generation is far greater in the front bank than in the intermediate bank, it is likely that under ordinary rates of driving no water is returned from the upper front drum to the bottom drum through any of the tubes in the front bank, but that all of the circulating water discharged into the front upper drum passes into the intermediate upper drum and down through the intermediate bank to the bottom drum. In general, there is a double-current effect in practically all of the tubes of the intermediate bank. The steam generated in these tubes passes up into the intermediate drum while the water carried along by this steam into the intermediate drum, as well as the water entering the same drum from the front drum, is conveyed by these tubes to the bottom drum. The circulating system of the Stirling boiler conforms in its elements to the simple arrangement shown in Fig. 3.

Atlas Boiler

The Atlas boiler consists of a nest of straight water tubes inclined at 1½ inches to the foot, the tubes being expanded into the front and rear headers, the latter similar to that of the Heine boiler. However, instead of having longitudinal drums, the Atlas boiler is equipped with cross drums and the front and rear headers are connected directly to the cross drums without any contraction in area at the points of connection. These two cross drums are merely continuations of the headers, being set with their axes horizontal and connected by two horizontal rows of tubes. In addition to these, there is a third cross drum above the other two and connected to them by simple rows of superheating tubes. The usual method of baffling is the same as that employed in the Babcock & Wilcox type with the rate of steam generation varying in a similar manner..

If all of the inclined water tubes discharge their contents into the front header, then the water must return to the rear header through the two horizontal rows of tubes connecting the front and rear drums. If, as is usually the case, the water line is carried at the middle of the upper row of equalizing tubes, in the front drum, then the effective water cross-section of the two rows of tubes is only three-fourths of their combined cross-sections. The equalizing tubes are of the same diameter as the inclined tubes and usually have a cross-section about 11 per cent. or less of the total cross-section of the water tubes. Therefore, the effective cross-section of the equalizing tubes for the return of the circulating water to the rear header is about 9 per cent. of that of the inclined tubes. While the throat area of the front header of the boiler is greater in proportion to the area of the combined inclined water tubes than that in either the Babcock & Wilcox or the Heine boilers, yet there is a considerable decrease in the cross-section of the circulating system at the equalizing tubes.

With the Atlas boiler operating at or near the rated capacity, with the water level at the center line of the upper row of equalizing tubes in the front drum, the water level in the rear drum is below the lowest point of the lower row of equalizing tubes. Hence, the water from the equalizing tubes discharges into the steam space of the rear header and there is no continuous water circuit.

It is generally assumed that the circulation in the Atlas boiler is as follows: All the inclined water tubes discharge into the front header and up this header into the front drum, from which the water returns to the rear header through the equalizing tubes. It is likely, however, that a large part of the circulating water returns from the front to the rear header through the upper rows of inclined tubes, as the upper rows do a comparatively small amount of work at ordinary rates of driving.

Wickes Boiler

The Wickes boiler is a well known type of vertical water-tube boiler. It consists of a nest of straight vertical tubes expanded at the top and bottom into two drums, set with their axes vertical. The furnace is exterior to the setting and by means of a single vertical baffle the nest of tubes is divided

into two parts, making a two-pass boiler. The gases from the furnace travel up along the entire length of tubes in the first pass and down the entire length of tubes in the second pass, escaping to the breeching at the bottom of the setting. The tubes in the first pass do much more work than these tubes in the second pass and it is probable that at all rates of driving, the circulation of the steam and water in these tubes is from the bottom to the top. The tubes in the second pass must return to the lower drum the water discharged into the upper drum by the first-pass tubes, and as there is a certain amount of steam generated in these tubes, which travels upward, there is a countercurrent effect in many, if not all, of the second-pass tubes. The water level is carried well above the bottom of the upper drum and the whole nest of vertical tubes is completely submerged, forming a continuous water circuit.

Cahall Boiler

The Cahall vertical boiler is similar in cutward appearance to the Wickes boiler, but differs materially in its circulating system. This boiler consists of a nest of tubes expanded at the top and bottom into drums set with their axes vertical, an opening being left through the center of the upper drum for the escape of the gases. The furnace is exterior to the setting and the baffle arrangement is such as to compel the gases to pass from the furnace through the entire nest of tubes from the bottom to the top where they escape. With such an arrangement of baffles there is but one pass and the gases do not reverse their direction. The tubes nearest to the furnace do more work than the rear tubes, but there is less difference in the rates of steam generation by the individual tubes than in any of the previously described boilers. Therefore, there is less tendency for the circulating water to return to the bottom drum through some of these water tubes. If there were no tubes nor pipes other than those mentioned, it would operate in a manner similar to the elementary boiler shown in Fig. 1 and would tend to prime excessively. In the Cahall boiler, however, there is an additional pipe connection between the top and bottom drums, this connection being run outside of the setting. Thus, no steam is generated in the return pipe and no opposition is encountered by the circulating water in passing through this return pipe. A countercurrent effect in any of the water tubes of this boiler would be decidedly more objectionable than in any of the previously described boilers. If, however, the return pipe is of sufficient cross-section and is properly located, it is unlikely that the countercurrent effect in the water tubes will be serious enough to cause priming.

Erie City Boiler

The Erie City vertical water-tube boiler consists of a top and a bottom cross drum connected by three banks of vertical water tubes, all tubes being curved at their ends so as to enter the drums radially. The furnace is exterior to the setting and the baffles are so arranged as to compel the gases to travel up the entire length of the front bank, down the entire length of the intermediate bank and finally up the rear bank to the breeching. The heating surface in the front bank is somewhat greater than that in the intermediate bank and about one-third more than that of the rear bank. The front bank does far more work than the other two combined, while the intermediate bank exceeds the rear bank. The circulation in the tubes of the front bank is probably always from bottom to top, with no countercurrent effect. The bulk of the circulating water returns from the top to the bottom drum through the rear bank of tubes, as there is less opposition to a downward flow in this bank than in the other two. However, as there is a small amount of steam generated in the rear bank, a certain countercurrent effect exists, but not enough to seriously interfere with the circulation. In the intermediate bank the circulation at ordinary loads is probably from bottom to top, although under certain conditions no doubt part of the water is returned to the bottom drum by the middle bank of tubes.

It would seem from the foregoing that the ideal circulating system for a water-tube boiler would conform to the following requirements:

1. All parts of the circulating system should be so arranged as to cause no oppositon to the flow of the water either by frictional resistance or by the presence of a force tending to oppose the circulation. This would necessitate all steam generated in parts not horizontal to flow in the direction of the general circulation and would preclude the presence of a mixture of steam and water flowing in one direction and of water flowing in the opposite direction.
2. All parts of the circulating system should be so arranged as to be below the water levels, giving a complete water circuit and eliminating the discharge of water into the steam space.
3. The circulating system should be so arranged with respect to the other parts as to permit the steam to leave the system at the proper points without interfering with the circulation.

While no commercial boiler fulfils completely these requirements, yet the more a boiler deviates from these requirements, the greater will be its tendency to prime, especially at high rates of driving.

Liberating Surface

The liberating surfaces of a water-tube boiler are the water surfaces at which the steam disengages from the circulating system and enters the steam space. As the tendency of steam to pick up water varies with its velocity, it follows that the greater the liberating surface, if properly located, the less will be the moisture carried by the steam and the less will be the amount of priming.

It does not follow that a boiler having a large water surface has a correspondingly large and effective liberating surface; in fact, the reverse is often the case, as most of the steam generated in the boiler leaves the water through a comparatively small part of the water surface. In boilers of the Babcock & Wilcox and the Heine types more than 90 per cent. of the steam generated is discharged into the drums by the front headers; and as there is a tendency for the steam to leave the water by the shortest path, only the water surface directly over the front header is true liberating surface. The remainder of the water surface in these boilers is simply liberating surface for the steam generated by the heating surface of the drums. The velocity of the steam leaving the water surface over the front header would greatly exceed that at other parts of the water surface; hence, the steam would contain more moisture as it entered the steam space just above the front header than in other parts of the drums.

In the Stirling boiler the water surfaces in the three upper drums are liberating surfaces, but the amount of steam generated in the rear bank of tubes is so small compared to the other two banks that the liberating surface in the rear drum has little or no effect upon the quality of the steam. As the front bank of tubes generates more steam than the other parts of the boiler, and as all of the steam generated in this bank leaves the water surface in the front drum, the amount of priming in this drum exceeds that in the middle drum. Hence, the liberating surface in the front drum has a far greater effect upon the quality of steam leaving the boiler than has the liberating surface in the middle drum or the rear drum.

In the Atlas boiler the water surface in the front drum constitutes the entire liberating surface of the boiler. The comparatively small amount of steam discharged with the water, by the equalizing tubes, into the rear drum enters the drum in the steam space; hence is not liberated from the water surface of this drum. There is practically no steam liberated from the water surface of the rear header; consequently all the steam generated by the entire bank of inclined water tubes is liberated at the water surface of the front drum.

The liberating surface of the Wickes boiler is the water surface in the top drum. On account of the manner in

which the gases pass over the vertical nest of tubes the velocity of the steam leaving the front half of the liberating surface greatly exceeds that in the rear half; hence the steam entering the steam space of the drum will contain varying degrees of moisture, depending upon the point at which it leaves the liberating surface.

The liberating surface of the Cahall boiler is the water surface in the top drum. As an external circulating path is provided for the return of the water from the top to the bottom drum, and as there is not a wide variation in the rate of steam generation by the various tubes, it is probable that the velocity of the steam leaving the water is fairly uniform over the entire surface.

The liberating surface in the Erie City vertical boiler is in the top drum directly over the banks of tubes and on account of the way in which the boiler is baffled, the degree of moisture contained in the steam leaving the water surface will not be very uniform, but will vary according to the location.

Steam Space

Liberal steam space is a valuable feature for water-tube boilers, as it minimizes the amount of moisture in the steam leaving the boiler and tends to prevent slugs of water from being discharged into the steam line. It also serves as a separator and receiver for the steam after it has left the disengaging surfaces. The relative position of the steam space with respect to the liberating surfaces has an important bearing upon the value of the steam space as a separator. The steam as it enters the steam space from the liberating surfaces contains more or less water in suspension. If, after leaving the liberating surfaces, the steam is compelled to travel for some distance at a velocity considerably less than that at which it left the liberating surface, a large part of the entrained water will be dropped and the steam will be much drier at the boiler nozzle. It is also essential, in order to secure the best possible separator action, to locate the steam space between the most active parts of the liberating surface and the steam outlet. Certain water-tube boilers have a comparatively large steam space, but that part of the steam space acting as a separator is not a large portion of the whole.

A reciprocating steam engine operating with the cutoff at 25 per cent. stroke takes steam from the line for a period corresponding to ¼ of the stroke and for the remaining ¾ no steam enters the engine. If no steam space existed between the engine throttle and the liberating surfaces of the boiler, the velocity of the steam leaving the water surface would be four times as great as it would be if the same amount of steam were supplied continuously and at a uniform rate. Interposing a receiver between the liberating surfaces and the engines tends to minimize this effect and allows a more uniform flow from the liberating surfaces, thus decreasing the steam velocity and, therefore, its tendency to carry over water. A large steam space is especially desirable in preventing excessive priming when a heavy load is suddenly thrown on the boiler.

In boilers of the Babcock & Wilcox and the Heine types the entire steam space in the longitudinal drums acts as a receiver, but only that volume of the steam space between the front header and the steam outlet is valuable as a separator. The nearer the steam outlet is to the discharge from the front header the greater will be the tendency of the boiler to prime.

In the Stirling boiler the steam space in the three overhead drums and the short tubes connecting these drums, acts as a receiver; but only the steam space in the front and middle drums and the connecting tubes is valuable as a separator.

In the Atlas boiler the steam space in the front and rear header drums, in the steam drum and in the two rows of steam tubes connecting the steam drum with the front and rear drums, acts as a receiver, but practically only the steam space available in the front and steam drums, and the steam tubes connecting these drums, is of value as a separator.

In the Wickes, Cahall and Erie City boilers the steam space available in the top drum is advantageous both in the capacity of receiver and separator.

The volume contained in the steam piping between the boiler outlet and the points of consumption helps a boiler so far as its priming tendency is concerned, providing proper drips are supplied. This is principally on account of its capacity and consequent receiver effect. A well designed boiler should not, however, be dependent upon the steam line in order that it may work successfully.

Water Space

It is not possible for the furnace of any boiler to instantly respond to a sudden demand for steam; consequently this is automatically taken care of by a sufficient drop in the steam pressure to evaporate the required additional amount from the water contained by the boiler. Evidently the greater the water capacity of the boiler up to the normal water line, the less will be the instantaneous drop in pressure, due to a sudden increased demand for steam, and the tendency of the boiler to prime excessively or to send slugs over into the steam line will be decreased. The water capacity of the drums of a longitudinal-drum type of boiler is particularly effective in this respect.

Many boiler waters contain impurities which have a tendency to make the boiler prime, especially at high rates of driving, the compounds of sodium and potassium being particularly troublesome. Such impurities, however, do not cause appreciable trouble until they have reached a certain concentration in the boiler. They do not leave the boiler with the steam, but remain in solution in the water and the longer the boiler is operated without changing the water the greater will be the concentration and hence the priming tendency. It follows then that, other things being equal, the greater the water capacity of a boiler, the longer it will operate under given load conditions without priming.

Uniformity of Water Level

The water level of a water-tube boiler when in operation may stand at approximately the same hight throughout the boiler or it may be at different hights, depending upon the design. Boilers consisting of a bank of inclined tubes terminating in front and rear headers and the latter connected to overhead longitudinal drums, will have a single water level and this level will not vary to any great extent with the output. Boilers having a bank of inclined tubes terminating in front and rear headers with the latter connected to independent cross drums, will have different water levels in the front and rear drums when the boiler is operating, the higher level being in the front drum; the harder the boiler is driven, the greater will be the difference in the two water levels. Where there are three banks of tubes terminating in three independent cross drums at the top, there will be three different water levels, the highest level existing in the drum connected to the most active bank of tubes.

The ability of a boiler to operate under all conditions of load without priming excessively or sending quantities of water into the steam line, depends to a certain extent upon the steadiness of the water level, especially at the most active liberating surface. The level of the water at this point varies with the output and a sudden increase in the load may raise the water level high enough to cause serious priming. Conversely, a sudden decrease in the boiler output will cause the water level to drop in the most active drum, this being particularly marked where the boiler is operating at a large output and the generation of steam is suddenly stopped by some furnace trouble, such as the abrupt appearance of large openings in the fuel bed, etc. Under such conditions unless care is taken, the fluctuation may exceed the limits of the water column.

Throwing a Brick Stack

By A. D. Williams

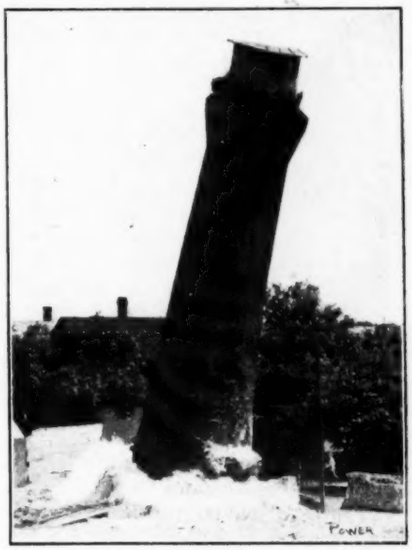
In making room for a new building upon the property of the National Electric Lamp Association in Cleveland, it became necessary to remove an old chimney which had been built for the Brush Electric Company about 27 years ago. It was decided to throw this chimney, and as there were dwelling houses about 20 feet from its base and about 50 feet away at the side it was necessary to lay it down in such a way as to avoid damaging them. In this case it was necessary to guard against all danger of the stack kicking back and the nearest house was so close that a screen was erected to prevent its windows from being broken.

Fig. 1. Cutting Notch to Center Line of Stack

Two holes were cut in the sides of the chimney just in back of the center and away from the direction in which it was desired to fell the stack. Then a gap or notch was cut in the side toward which the chimney was to fall, the size of this notch being increased until the load became so great that the brick between the previously cut holes and the notch crushed. This process proved successful and the stack fell exactly where it was wanted.

The chimney was about 6 feet square inside at the bottom and about 4 feet square at the top and had an 8-inch firebrick lining separated from the exterior wall by a 2-inch air space. The red-brick wall at the base was 17 inches thick, about 90 feet high, and contained approximately 109,000 brick, weighing 305 tons.

Fig. 1 shows the chimney shortly before it started to fall with the men enlarging the notch which nearly reached the center line of the stack. Fig. 2 shows the chimney just after it started to fall. The external wall began to crumple down on itself and the firebrick lining projected above the top carrying the tile coping. The wall on the downward side has started to break up in this illustration and the base of the chimney appears to have slid to the ground; this is shown better in Fig. 3, where about half of the lower portion of the stack is on the ground and the top is still falling. The firebrick lining projects nearly 20 feet above the red brick.



....Fig. 2. Stack Starting to Fall....

The Opportunities of Municipal Ownership

The value of municipal ownership is set forth in a recent public address by C. W. Koiner, manager of the municipal lighting plant at Pasadena, Cal., a subject with which Mr. Koiner is thoroughly familiar. The Pasadena plant is one of the most successful in operation; it has a 5-cent lighting rate and is said to net a return of 11 per cent. on its investment. He declares that the advantages of municipal ownership are really beyond the comprehension of the average citizen, and that people are just beginning to realize its possibilities in the governing of all public utilities.

It has been demonstrated by a number of municipalities scattered throughout the United States, Mr. Koiner said, that when a city is ready and wants municipal ownership of any of its utilities it can operate them and secure results in the way of low rates and good service far beyond the expectations of the average citizen. No community which conducts its affairs on a partizan basis can ever be entirely successful in the operation of any of its utilities, because with every change of administration there would be a change in the employees and heads of such departments, and the policy and management necessarily would be changed.

Municipal ownership will be successful only in the cities where it is insisted that all officers and heads of departments be qualified for the offices they hold, Mr. Koiner said. Coupled with this requirement, municipalities must expect to pay their employees a liberal salary for the service rendered, and unless a city is willing to give just compensation it cannot hope to secure the type of employees that it must necessarily have to conduct its public utilities. The utility corporations will take from the city, State or nation its best men at higher salaries unless the public is willing to pay an equal salary for the kind of service it demands and must have.

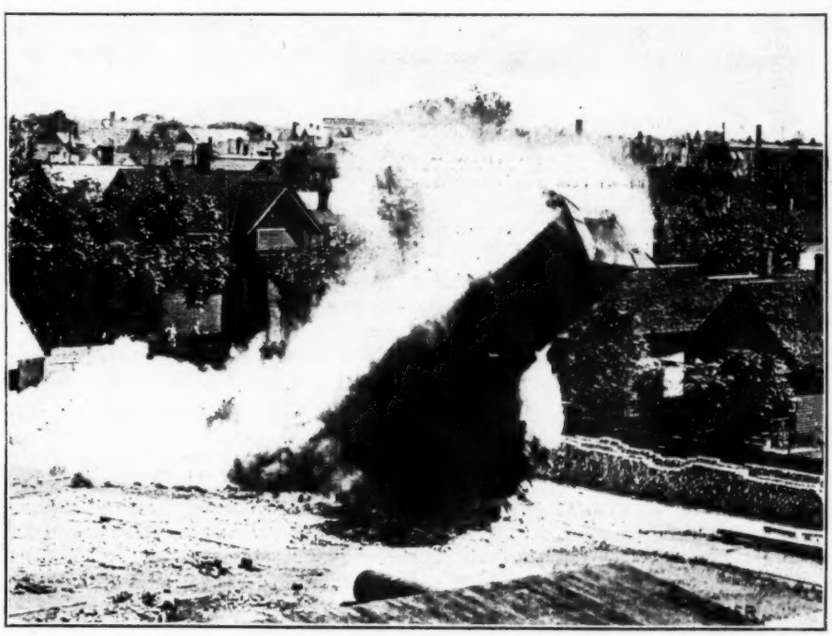


Fig. 3. Lower Part of Stack on Ground and Top Still Falling

Teaching Operating Engineering*

By J. A. Pratt

Very few opportunities exist for a young man to learn operating engineering in a systematic and thorough manner. The Williamson Trade School trains operating-engineering apprentices in fundamental principles and gives them actual shop and power-plant practice.

*Abstract of lecture delivered at annual meeting of the Institute of Operating Engineers, New York, September 1, 1911.

The time was, and that not so many years ago, that running an engine was regarded more or less as a laborer's job, if a man could start and stop a machine, and have it in such a condition that the crank would turn, he had fulfilled about all the requirements, and no one cared for or wanted anything more, especially in the small plant. Today, the man in charge of a single unit even, has an opportunity, whether he embraces it or not, to give evidence of ability. If you talk with the average man running a plant you will find in most cases that he regards himself as efficient as is necessary. It would not do him any good if he did run the plant more economically, he says, so he does not think it worth while to get a full knowledge of his line of work. To him I would say, get the knowledge and condemn afterward, if he wishes to do so.

There are three fundamentals to be considered in studying the attitude of such a man and the following questions suggest these elements:

First: Is it because he has not had an opportunity to obtain proper guidance in the study of his work, that he is not a master of it?

Second: Is it because he is too lazy to keep himself always up to concert pitch?

Third: Is it because he is asked to work such long hours and so hard, in such close, poorly ventilated engine rooms, that no human being could be at his best *cny portion* of the time, to say nothing of *all* the time?

The men who have had the organization of the Institute of Operating Engineers at heart have been thinking of just such questions as these, and it is the purpose of its life to put the operating engineer in such a place that he will be recognized for what he ought to be, a practical man, with lots of common sense and a good education, worthy of just and fair consideration and capable of producing a handsome return on his pay as an investment. Pretty close to the professional do you say? Very well, let it be such; then we have an operating engineer in the full meaning of the term.

I am not planning to speak on any of these questions except the one of training the man, and not on the whole of that. I will confine my remarks to that which bears on the first steps—his apprentice career, up to the time when he can meet the requirements of a journeyman machinery operator, as outlined by the educational committee of the Institute of Operating Engineers.

Relative to the lazy man, I will just say that by some means he must get inspiration; either by discipline or example, and a correct view of life's great values. Briefly, he must get for himself a prettier and more wholesome picture of work. With this I will leave the drone.

As to conditions of life, I wish to say that if one considers the man behind the power plant as nothing but an investment in cold hard cash, the best way to get a high rate of interest on such investment is to put the man in such surroundings, require such hours of work and set him in such relation to the management, that he will feel like a man whose opinion is of value, and thus be induced to work in such a way that he will have opinions, and good ones at that. You cannot get much of a return from any person if you place him in conditions such as you could not stand yourself if you were holding his job. A whole course of lectures could be delivered on the status of operating engineering alone; but it would be manifestly unwise for me to attempt to discuss this as a topic when my principal theme is another feature of the work, so I will simply say that it is a paying investment when dealing with *any* man to do as you would be done by—a golden rule in more than the commonly accepted sense. Reasonable hours, reasonable time for recreation, reasonable dealing, are things we must give if we expect the largest return.

Up to the time when those who are responsible for the Institute of Operating Engineers began its organization, the opportunity was very limited for a young man to develop himself thoroughly by following a regularly laid out and arranged course of work, by means of which, when completed, he would receive recognition as an engineer on the part of authoritative persons, capable of passing on his qualizcations. It is granted that there was a license system, but a license is quite variable in its meaning, and its requirements are not the same the country over. The plan and scope of the Institute, however, give an opportunity to every person in the field who is willing to work to become a well trained engineer who will receive recognition of his status, free from any influence of polity or makeshifts of chance. His success in gaining this station depends not simply on a set of questions, but on a record of application to a purpose which shows a tried and trustworthy man and vouched for by parties well acquainted with his work who are more capable than himself, both as to theory and to application in practice.

A point on which I feel that I ought to touch is one relative to the so-phrased machine-made engineer, of which one hears at times. Machine-made, as intended by those who use it, refers to a man with a kind of exterior veneer but with no real knowledge of the power plant in practice. I would refer any who entertain this idea to the pamphlet issued by the Institute presenting the practical requirements of the apprenticeship grades; he will find that before a young man can become a journeyman machinery operator, he must be able to do the practical work around the plant in an efficient manner.

The advantage which the young man has in associating himself with the Institute of Operating Engineers is not that somebody will say he is an engineer when he is not, but that, due to the careful guidance which is at his service, he may become an engineer much sooner than would be possible without direction, as he is not misusing his energy in trying to study something which he cannot understand because of lack of preparation or in spending his time on work not directly applicable to his calling.

Some are expressing the fear that there may be so many really good engineers that pay will be materially reduced or, to put it briefly, the field will be overcrowded. This overcrowding of fields of endeavor is so much of a sociological problem, with the matters of form of government, class relation and personal initiative entering into it, that it cannot be discussed in this paper; we may rest assured, however, that just as long as we follow the good American plan of letting every fellow rise just as high as his ability will permit and do not allow to develop the idea that because a boy's father was a day laborer the boy, perforce, can be nothing else, we need not fear too many good men in any line.

I have already mentioned the fact that up to this time there has been very little in the way of an arranged guide for the young man who wished to become an

operating engineer; such a one was left largely to his own devices. But there has been direction for the apprentice and it may be interesting to know what were the requirements for the beginning of such work, the outline of the young man's first steps in his trade, how he progressed, what he did and his recognized status in the field after completing the course. So I will present an outline of the course that is offered at the Williamson Trade School.

The applicant must be at least 16 years of age and is required to pass an examination in the following elementary subjects: Reading and writing in English, spelling, arithmetic, including weights and measures, fractions and interest, geography, American history, composition and elementary English. This examination is not severely rigid, but a boy must show reasonable proficiency in the subjects mentioned before he may enter on the course. His first year is devoted to shop and academic work, spending four hours a day in the class room and four in the shop, with a half day off on Saturday. The academic work is under a teacher who gives attention to nothing but class-room work, while the shop work is under the instructors in machine work and operative engineering. The academic or purely school-room work during this period embraces the following subjects, in each of which the student must satisfactorily qualify in order to remain at the school:

Arithmetic, grammar, geography, American history, reading, literature, physiology and hygiene. In the shop during the same period he covers the following work, arranged in sequence for his proper development: Plain chipping, using cape and broad chisel. Use of steel stamps, inside, outside and micrometer calipers, general methods of laying out work, lacing belts, reading speed indicators and study of shafting layout. Flat filing (crosscut and draw) work at forge in cutting off, upsetting, fullering, flatting, finishing and tempering. Soldering, sweating, use of threading dies, taps and ratcheting. Lathe operation, including centering, parting, facing, straight turning, shouldering and chamfering, truing centers, filing, chuck work, right- and left-hand thread cutting, taper turning and fitting. Drill-press operating, including reamer, tap and pipe work to layout, countersinking and counterboring, and various methods of handling cylindrical work. Shaper operation, including parting, use of shoe or vise, down cutting and surface work, cutting keyways and planing to geometrical form as hexagonal or octagonal work.

In reviewing this shop work it should be kept in mind that the boy is *taught;* he is not left to himself to get some kind of a passable result which may have been obtained by very poor methods, but his teacher constantly visits him, giving the points of nicety and refinement which, after all, really classify the man as to his quality in the trade. This same method holds throughout his whole course, the aim on our part being to see that the boy knows what he is doing, why he does it, and that his method is correct.

During the first year, the school-room work takes place from 8 to 12 in the morning and the shop work from 1 to 5 in the afternoon, class-room routine being the same as is customary in most industrial schools, the class going for a certain period to one teacher for grammar, another for arithmetic, another for history, etc. When entering the shop in the afternoon, the class first goes to the department class room, where after roll call a shop talk is given, being one of a series, which bears directly on the working features of the trade.

The general headings of shop talks covered during the freshman year take up the allied information necessary for the successful handling of the work already presented under the shop headings. The notes taken by the boy in these talks are turned over once each week for inspection by the shop teacher, and their completeness coupled with the appearance determines a mark which goes as a part of the apprentices' permanent record.

During the first year of his apprenticeship the boy spends about two weeks in the fire room, one day at a time, becoming familiar with the room routine, parts and general construction of the boiler and the first elements of firing.

At the end of the first year the boy begins to spend his entire shop period in the power plant. He can now chip, file, scrape, forge, babbitt, lay out and can run a lathe, shaper and drill press fairly well, so he is fit to start his study of the purely operative side of the equipment in an intelligent manner.

During the second year, the apprentice will cover work involving the following principles, and their application in practice: Classification of power-plant supplies; systematic storing of supplies, cutting, threading and general pipe fitting; general electrical fitting, including splicing, taping, soldering, light wiring, socket and switch repairing and fitting, including ceiling, wall and bracket work together with bell work; handling of the boiler accessories, including feed valves, gages, surface and bottom blows, injectors, safety valves, fusible plugs and draft regulators; regular fire-room duty on watch.

By such means the young man becomes well acquainted with general power-plant conditions in their various details, and is trained as a fireman. During this year his work is entirely under the instructor in operative engineering.

As in the freshman year, a class-shop talk is given each day by the instructor on a subject bearing on the work being covered, the outline of which is as follows: Care of power-plant machinery in general; steam boilers; steam fitting; general handling of electrical equipment.

The method of marking notes is the same as has already been described.

The work in the academic department during this second year is as follows: Arithmetic, algebra, geometry, chemistry, physics, rhetoric, reading and literature.

During the last seven months of the apprentice's work in the course, the boy's time is eight hours a day in the power plant, all academic work being done in the evening during this period. This academic work is in the following subjects: Geometry, trigonometry and strength of materials. The shop talks by the instructor in the power plant carefully cover the subjects of steam, electricity, heating and ventilation, pneumatics, refrigeration, gas engines and producers, pumps and hydraulics, coupled with calculations and the making of tests.

The principles covered by actual work involve the upkeep of water-service lines, steam lines, care and operation of pumps, both steam and motor driven, gasolene engines, maintenance of battery equipment, operation of the air compressor, the handling of turbine and reciprocating generating units and the running of refrigerating plants.

Each year all units in the plant are tested under actual working conditions for the purpose of determining economy of operation. Such testing is covered as an exercise by the senior apprentices, each boy working out values and analyzing diagrams.

It should be borne in mind that no boy is held back or dismissed because he is somewhat dull; in fact, there are a number of men who today are holding good positions in power plants who would not be so pleasantly located were it not for patient and persevering teaching on someone's part when they were students.

As to the status of the young men after finishing such a course, I will say that most of them start in as assistants on some phase of power-plant work, and usually give reasonable satisfaction.

The advantage of a method of training under direction and teaching is that at a much earlier age an apprentice becomes a more successful earner, hence a more respected man and a better citizen, and the policy of the Institute of Operating Engineers in so carefully and thoroughly planning along such lines cannot but be commended. It is sure to meet with approval and success, bringing benefit to many and putting the operating engineer on that plane in industrial work which in all justice is his proper station.

With the use of petroleum by the transportation and manufacturing industries, California has practically done away with coal as a steam-raising fuel. Oil is also used in that State in making gas employed, for cooking, heating and lighting.

Heat Loss Due to Humidity

By John G. Moxey

At first thought it would seem almost incredible to state that the humidity of the air has a marked effect on the economic operation of a boiler; yet such is the case and, what is more surprising, we may use up as much as 10 or 12 per cent. of the heating value of the coal in just this way. By the term humidity, of course, we mean the amount of moisture present in the air as compared with saturated air under similar conditions as to pressure and temperature.

The amount of available heat used in overcoming the humidity is that necessary to raise the temperature of the moisture in the air from atmospheric temperature to the boiling point, to evaporate it at that temperature and to superheat the steam thus formed to the flue-gas temperature.

As an example we will take the data from a recent test run on a certain 650-horsepower water-tube boiler, using forced draft and burning semi-bituminous coal analyzing as follows:

Carbon	79.20 per cent.
Hydrogen	6.31 per cent.
Oxygen	4.22 per cent.
Sulphur	1.70 per cent.

having a heating value of 14,100 B.t.u. per pound. The flue gas in this case analyzed as follows:

Carbon dioxide	9.80 per cent
Carbon monoxide	0.30 per cent.
Oxygen	8.87 per cent.
Flue-gas temperature	570 degrees Fahrenheit
Boiler-room temperature	72 degrees Fahrenheit

The amount of air theoretically required to burn one pound of coal is computed as follows:

$$11.52\,C + 34.56\left(H - \frac{O}{8}\right) + 4.32\,S =$$

$$11.52 \times 0.792 + 34.56\left(0.0631 - \frac{0.0422}{8}\right) + 4.32 \times 0.01699 = 11.19 \text{ pounds of air}$$

required per pound of coal.

The accompanying table shows the heat losses due to various atmospheric conditions and various percentages of excess air. The results were calculated on the slide rule.

The curves show these results in graphic form.

LOSSES DUE TO EXCESS AIR AND HUMIDITY

Per Cent.		Loss in B.t.u. Due to		Per Cent. Loss Due to		Total Loss	
Excess Air	Humidity	Excess Air	Humidity	Excess Air	Humidity	B.t.u.	Per Cent.
0	100	0	282	0	2.00	282	2.00
	80		226		1.60	226	1.60
	60		169		1.20	169	1.20
	40		113		0.80	113	0.80
	20		56		0.40	56	0.40
	0		0		0.00	0	0.00
20	100	266	338	1.89	2.30	604	4.30
	80		271		1.92	537	3.81
	60		203		1.44	469	3.33
	40		135		0.96	401	2.84
	20		67		0.47	333	2.36
	0		0		0.00	266	1.89
40	100	533	395	3.78	2.80	928	6.58
	80		316		2.24	849	6.01
	60		237		1.68	770	5.46
	40		158		1.12	691	4.90
	20		79		0.56	612	4.34
	0		0		0.00	533	3.78
60	100	799	451	5.66	3.20	1250	8.86
	80		361		2.56	1160	8.24
	60		271		1.92	1070	7.59
	40		180		1.28	979	6.94
	20		90		0.64	889	6.30
	0		0		0.00	799	5.66
80	100	1066	508	7.56	3.60	1574	11.18
	80		407		2.88	1473	10.45
	60		305		2.16	1371	9.74
	40		203		1.44	1269	8.99
	20		102		0.72	1168	8.28
	0		0		0.00	1066	7.56
100	100	1332	564	9.45	4.00	1896	13.44
	80		450		3.19	1782	12.63
	60		338		2.40	1670	11.84
	40		226		1.60	1558	11.04
	20		113		0.80	1445	10.24
	0		0		0.00	1332	9.45

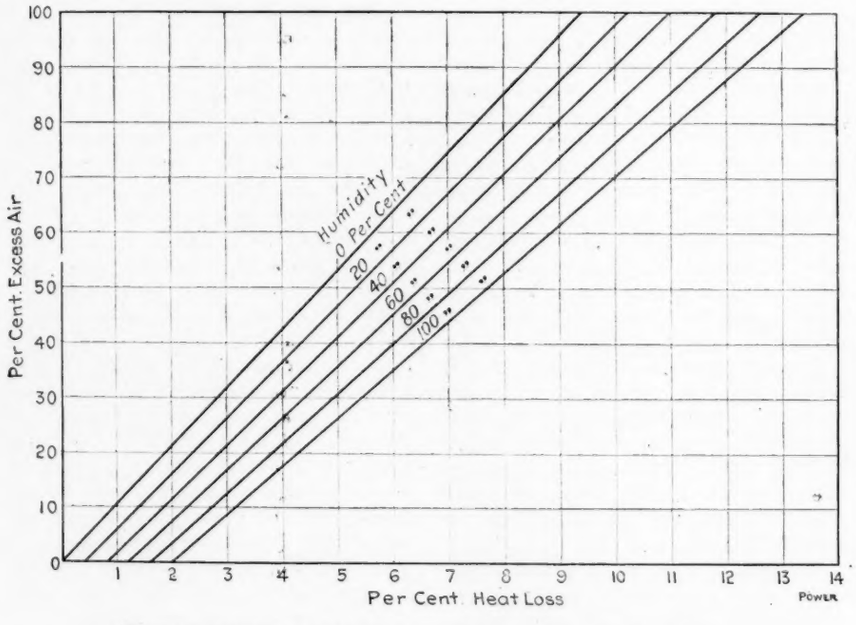


Diagram Showing Loss Due to Excess Air and Humidity

Is it any wonder then that the elements are to be reckoned with in boiler practice? With many blast furnaces we already have methods of drying and heating the air supplied, not only to reduce the actual coal consumption but also to give higher temperatures; it is therefore to be expected that in the near future engineers in general will be directing more time and attention to this consideration and will install some method to cut down this needless loss just as we now have economizers and feed-water heaters.

A Case of Overpressure

By J. E. Terman

Pat Casey was considered an old employee of the Red Bottle Distillery in New Orleans, for he had been firing the boilers for 10 years, and was the oldest member of the force. Although he rarely drew a sober breath during his connection with the distillery, yet his constitution was such that he had never been troubled with visions. When he spoke concerning what he saw, it was believed that something had actually occurred.

As everyone knows who is acquainted with the New Orleans climate, it is rarely cold enough there in the winter to form ice, and such an occurrence as the freezing of water pipes is almost unknown. During February, 1899, however, an exceedingly cold wave passed over the country, and the temperature went down to about 10 degrees above zero at New

Orleans. On the coldest morning during this unusual weather, Pat came to the distillery very early to get up steam and warm things up; he looked at the steam gages and, finding that they registered only 15 pounds pressure, he broke down the fires, which had been banked the night before, and started in.

Before long Emile Landry, the Creole engineer, came in and began to busy himself about the engine room, packing a gland or two and taking up the crank-pin brasses. Landry had only been hired a month previously when the old engineer had run off down the street fighting an imaginary pack of red and green monkeys. His excuse, when captured, was that a big red one was sitting on the throttle valve and bit his hands when he attempted to shut down the engine.

Landry, who had heard of the antics of his predecessor, and had observed the usual condition of the other members of the crew, had very little faith in any of them. When Pat appeared at the engine-room door on this particular morning with a wild look in his eye, and yelled for Landry to come to the boiler room as No. 2 was about to burst, he was sure that Pat had finally succumbed to the inevitable, and was "seeing things." Landry was a cautious fellow, however, and thought that he had better look around the boilers, and be sure that everything was all right. Accordingly, he stepped out to the fire room to take a look at the gages. He was horrified to find that the steam gage on No. 2 registered 245 pounds, while that on No. 1 showed 55 pounds.

Pat, who had been dancing around the room, suddenly had an inspiration.

"Faith, I will get on top of ther biler," he said, "and aize up on the safety valve and let the steam out."

Said Landry: "If you dare to go near one of them safety valves, I will brain yer with this fire hoe."

Landry began pulling the fire under No. 2, and about 15 minutes later the pressure had dropped to 40 pounds. He could not account for the rapid fall in pressure, but he considered it would be safe to inspect the lever-type safety valve. To his surprise he found the safety valve apparently free, and set for the usual pressure of 90 pounds. Having looked everything over carefully he told Pat to fire up again.

Pressure began to rise slowly and Pat retired to the distillery to brace his shattered nerves. He tarried a while to tell one of the crew of his narrow escape, and possibly 10 minutes elapsed before he again returned to the boiler room. One glance at the steam gage of No. 2 was sufficient for Pat. The pointer had just passed the last graduation on the dial, registering 300 pounds, and, with a whoop, Pat bounded through the engine room to the street, yelling to Landry as he passed, "Run fur yer life, Landry; she is goin' up."

Landry was no coward, however, and he felt that the safety of the plant and that of the crew was in his hands. He grabbed the fire hoe as he reached the front of the boilers and began raking the fire from under No. 2 boiler. In a short time the pressure dropped again to 40 pounds. He decided not to take any more chances until the boiler inspector could be consulted, so he finally coaxed Pat back on the job to fix No. 1 while he telephoned for the inspector.

Bill Grimes was the inspector in the office at the time the message came, and when he heard Landry say that No. 2 had over 300 pounds on her, and to come quick, Grimes replied: "Not by a d——— sight will I come unless you get her cold. I wouldn't go within 10 blocks of that old kettle if she had 150 pounds on her."

Landry assured him that there was only 40 pounds on, and that it would be considerably less by the time Grimes arrived.

When Grimes reached the distillery, Landry carefully described all the particulars; how he had examined the safety valve and found it free, and how the second time the boiler was fired the pressure had run up to over 300 pounds without blowing the safety valve. Grimes was puzzled at first and questioned Landry closely as to how many drinks he had taken that morning. But Landry was perfectly sober.

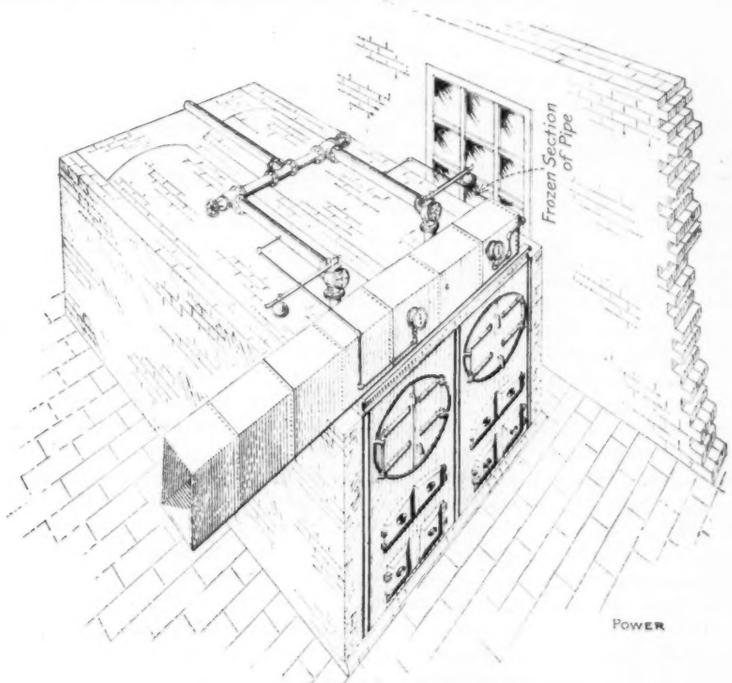
Grimes said he would go on top of the boilers and examine the safety valves himself; but he really went to examine the stop valves, to be sure that they were both open, as they should be for regular operation. Finding them all right he came down, and settling himself in the fireman's seat he put the following question to Landry and Casey:

"If I should connect a 6-inch pipe to the steam header and connect a steam gage to each end of it, then turn on the steam, and one gage showed 80 pounds pressure while the other one showed 300 pounds, what would you say was the matter?"

Both Landry and Casey answered in unison that one or both of the gages would be wrong.

"Well, it's funny," said Grimes, "that the two of you together should have so little sense that I must neglect real business to come up here to coach you on such questions."

"Do you mean," said Landry, "that there wasn't 300 pounds on the gage of No. 2 boiler?"



PIPE CONNECTIONS TO BOILERS

"I didn't say so, did I?" replied Grimes, "but if you will thaw out that pipe by the window that connects the gage of No. 2 and give the steam pressure a chance to act on it, you will find everything is all right."

The connection referred to ran by a window at the side of the setting and was frozen solid. As the gage and part of the connecting pipe were close to the breeching, the heat from the flue expanded the water in the front end of the pipe and gage so that the high pressure was registered.

After things were running smoothly, and Grimes had left, Pat said to Landry: "Well, what d'ye think of that, and me almost skeered into signing the pledge!"

"Well," says Landry, for the first time since he had been on the job, "let's get a drink, Casey," and they both hurried into the distillery.

Potblyn, Pump Doctor

By John Watson

The owner of the pump felt sure the trouble was in the pump itself. Potblyn discovered it to be otherwise, and incidentally met an engineer whose style he did not like.

Br-r-r! "Hello!"

"Hello! Is this Watson?"

"Yes."

"Well, this is Clark, at the Maddern mill. We have one of your pumps over here that is pounding infernal tar out of itself."

"Impossible," I answered. "We don't use any such material in our pumps and if what you state is so it must be something that you have put into it since it left here."

"Aw, quit your kidding. The facts are that we have one of your 7½ and 5 by 6-inch duplex outside-packed plunger pumps feeding our boilers and the blamed thing has given us a whole lot of trouble. The plungers and the steam pistons get loose, the plunger-rod keys break and we have been ordering repairs and patching the thing up until we are sick of it. I wish you would come over and have a look at it before we throw it into the scrap heap."

"Well, Clark, I cannot understand why the pump should act so. Is it handling hot water?"

"Yes."

"Any head on the suction?"

"About 4 feet, I think; but come over and see the thing for yourself."

"Can't now; I'm too busy," I answered. "I'll send over a better man who will fix you up if anybody can."

"All right, have him come right over. Good by," and Clark hung up the receiver before I could say anything further.

I sent for Potblyn, gave him his instructions and thought no more of the matter. About three-quarters of an hour later the telephone rang again; Clark was on the other end of the line and he was hot.

"Say! Watson, I thought you were going to send someone over here who knew something!"

"Yes," I replied, "I sent a man over; hasn't he got there yet?"

"Oh, yes, he's been here, but what the dickens do you mean by sending a mutt when I asked for a man to see what's the matter with your danged old pump!"

"Couldn't he fix it?" I asked.

"Fix it? he would not even look at it or take his coat off. He went into the engine room, turned round once, said the pump was all right and left. Don't you suppose we know the circus we've had with it the last six months? Something has got to be done about it, and done right quick, or it goes to the junk shop; your company's reputation goes with it, and we'll get a real pump from somebody else; see!"

"All right," I answered; "you put on the brakes and try to keep yourself from exploding for a little while and I will see what can be done." I turned to my work and waited for Potblyn, for I knew that as soon as he got back he would come up to see me and probably have an interesting story to tell that perhaps would not quite agree with Clark's.

In a short time he came in and flopped into a chair.

"Well, Doc?" said I. "Mr. Clark is rather hot. He says that you never even looked at the pump; that you said it was all right and came away without any explanation. Now tell me what is the trouble and we will go over and see him."

"All right, Mr. Watson; I'll go over with you if you say so, but if I do, they've got to keep that man Johnson, their engineer, out of the way or I'll make him look like a small handful of small change. I kept my hands off from him before, but I don't think that I could do it again for he's the worst loud-mouthed slob I ever ran up against. As soon as I got in there he began damnin' the pump and the Blank Pump Works. He kept up such a string of it that it made me sick, and I ain't no chicken either. That darn fool didn't know what he was talking about.

"He says I didn't look at the pump, does he? Well, I did look at it, and it took only one look to see what the trouble was, and it wasn't with the pump either. I'd have told him about it if he had been anyway decent, but I just couldn't talk to him so I came away.

"I can't stand these knockers! Most engineers are good fellows and anxious to learn any little kink and will try to help a fellow all they can, but sometimes you meet one that when he has trouble in the place he spends his time 'knocking' the machines. Usually those fellows know very little, and the trouble is with some of their connections instead of the machine. You can't tell 'em anything. Kicking does not make an engineer, and this man Johnson is no engineer; he's just a plain ornery mule. I'll tell Mr. Clark what's the matter if you say so, but if there's too much Johnson, there'll be a smash-up sure."

"Well, what is the matter, Doc; why didn't you examine the pump?" I asked.

"Didn't need to," he replied. "You see it's this way; they've got an outside-packed plunger pump for boiler feeding. It handles red-hot water, and takes it from a big tank or heater. There is about 4 feet head on the pump and a steam pressure of about 4 pounds on the tank. You would naturally think that there would be no trouble in getting the water to the pump. But that's the joker; they don't always get water to the pump. Quite a lot of make-up water is needed for the system and they have a float in the tank that operates to let in cold water when the level falls. It lets this cold water right into the steam in the upper part of the tank. This condenses some of the steam and reduces the pressure and away goes the pump!"

"But what if it does condense some of the steam, Doc; isn't there still some pressure in the tank and four feet of water head on the suction? That ought to get water into the pump all right," said I.

"It looks like it," said Doc; "but it don't do it. I've been up against this same sort of thing lots of times and have been looking for the answer, but never saw anything printed about it. This is how I dope it out: It is the same sort of thing that you are up against on a pump and receiver collecting hot-water drains and putting them back into the boiler. You see, when pumping hot water all of the time the castings of the pump end get hot and are just about of the same temperature as the water; there is what I call a heat balance established. Now, when you suddenly let cold water into the receiver at the other end of the line you put the system out of balance. What happens? The pressure is lowered, the temperature of the water is reduced and the pump castings give up some of their heat to the water in the pulsation chambers and suction of the pump. This is just enough to vaporize some of the water, and all that the pump gets is vapor; you know what happens then. Any pump under these conditions will slap-bang some and produce just the troubles that they've had over there. As soon as I saw their hook-up I got more interested in that than I did in the pump, for I knew that it was dead wrong. I'll bet a hundred dollars to a plugged nickel that I can go over there and make that pump slam to beat four of a kind; and I won't touch anything about the pump either."

"All right, Doc, let's go over and have a look; I want to see you do it," I replied.

We went over to the Maddern mills and got Mr. Clark to go down into the engine room with us. A little preliminary explanation as to the trouble and the attitude of his engineer led him to say a few sharp words to that worthy, the sub-

stance of which meant "Shut up," and so we were spared the chance of a mix-up between Doc and the "engineer."

The pump was running as well as one could wish; just a slow, steady stroke.

"Now watch her," said Doc. He went over to the tank and manipulated the float lever so as to let in a sudden supply of cold water. He would certainly have won the plugged nickel if we had bet, for, sure enough, the pump started off on a career of its own that promised to lead speedily to destruction. Doc started to explain the matter to Mr. Clark, but the latter did not care much about the cause. He had become convinced that the fault was elsewhere than in the pump and his temper had cooled off until it was back to normal.

"Well, now you have found out the trouble," he said, "what can we do to overcome it?"

"It's a rather hard matter to wholly overcome it," Doc answered. "You have got to arrange to keep that suction supply as near an even temperature as you can, for it is the sudden changes in that which cause the trouble. If it was mine I'd put a large vent pipe on that tank instead of carrying a pressure. Then condensation of the steam wouldn't make such a reduction in the pressure. Furthermore, I would arrange to take in the cold water close to the pump instead of into the vapor space of the tank; then any disturbance of the heat balance would send the flow of heat toward the pump instead of away from it. Then I'd take that engineer out and turn the hose on him!"

With this parting advice we left. On the way back to the works, Potblyn said: "I don't feel wholly clear in my mind about this business, Mr. Watson; I've thought a lot about it and I've doped it out the best I know how, as I've explained to you; but I'd like to know what some of the other fellows think about it and how they reason it out. I wish you would write to POWER and ask if any of the boys have had similar experiences and how they got over them."

What do you say, fellows?

Most Economical Amount of CO_2

BY A. BEMENT

As there is much confusion of thought on the significance of the CO_2 determination as applied to furnace fires, the following may be of interest:

The principal difficulty appears to be that sometimes CO_2 and efficiency realized, in steam generation, do not correspond; in other words, in some cases the CO_2 increases but the efficiency does not. This fact has led to the use of the expression "most economical point of CO_2," based upon the assumption that some point below the maximum might be more economical. A recent committee report stated that there is some undefinable relation between CO_2 and efficiency that is controlled by some unknown influence due possibly to the differing velocity of the gases in their passage over the heating surface.

Combustion with the highest CO_2 should in all cases give the highest efficiency in steam generation. If it does not, there is some counteracting influence at work, because the higher the CO_2 the higher the temperature of combustion, and higher temperature produces greater efficiency.

With many furnaces and methods of firing there is often a more or less serious loss of undeveloped heat in hydrocarbons which escape unburned, and therefore it is practically impossible to detect the presence of such hydrocarbons in the combustion gases by any analytical process because of their small volume. So it has come to be believed by many that if there is no carbon monoxide found, that combustion is complete

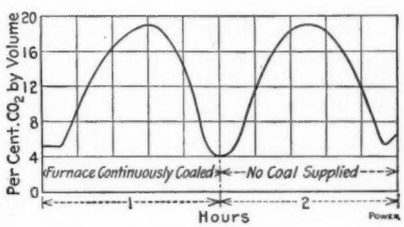


DIAGRAM SHOWING EFFECTS OF VARIATIONS IN FURNACE OPERATION

and hence that the significant components are CO_2 and air, and that the control of the combustion process is only a matter of regulating the air supply. Thus there is a belief that the amount of CO_2 is sufficient in all instances, and if efficiency does not increase with it, there is a disposition to blame the CO_2 for some supposed fault, when, in fact, such demonstration should be accepted as evidence that something else is wrong which should be sought and remedied. I have found it necessary in making proper use of the CO_2 determination first to produce a condition of uniformity so that the CO_2 would remain constant, and then to increase or decrease it by increasing or decreasing the air supplied or the quantity of fuel fed. If this is done, the CO_2 may be built up and the maximum possibility of the furnace or condition demonstrated.

If the mixing capacity of the furnace is ideal, it is possible to realize theoretical CO_2. With irregular firing or bad stoker action, neither a high CO_2 nor complete combustion is attainable. It is, of course, true that if bad conditions do prevail the "most economical" amount of CO_2 is a factor of importance, but a remedy for such state is of much greater value than a knowledge of what is the most economical CO_2 under the faulty condition.

The fundamental difficulty now is that the significance of CO_2 in its relation to excessive air supply is the only feature that has had much attention. The other and almost as important one, that of excessive or irregular fuel supply, is neither understood nor properly appreciated.

There are four features of importance which may be considered as guiding principles in the employment of CO_2 determination, as follows:

1. If CO_2 increases after the supply of fuel or the reduction of draft, it shows that air has been in excess.
2. If CO_2 falls, following the supply of fuel, it shows that incomplete combustion has been produced.
3. If the CO_2 is irregular and uneven, it indicates a corresponding condition of combustion.
4. Assuming constant or uniform condition of combustion, if impossible to realize high CO_2, it is an indication of deficiency of the furnace in its ability to secure good mixture of the gases.

The accompanying diagram may be of interest as illustrating the matter under discussion. During the first hour coal was supplied, but none during the second hour as designated. At the start of the first hour CO_2 was low, about 5 per cent., due to excessive air, or in other words, deficient fuel. Fuel was then introduced at a regular but excessive rate which brought the CO_2 to 19, after which, as the fuel supply continued, the CO_2 declined, due to incomplete combustion, which was caused by this excessive fuel. When it had dropped to 4 per cent. the coaling was discontinued. Then the excess fuel burned away gradually until the combustible and air supply arrived again at a balance at 19. After this, owing to the fuel continually growing deficient, the CO_2 dropped to about 6.

With this experiment, if the prevailing conditions are considered in connection with the amount of CO_2, we learn that during the first half of the first hour, a decreasing excess of air caused the rise in CO_2 and that during the second half the fall was caused by the excess of fuel, which was necessarily accompanied by incomplete combustion. With the first half of the second hour, a rise in CO_2 was caused by decreasing the fuel supply which arrived at a balance with air at 19, after which, as no more fuel was added, it dropped, due to increasing the excess of air to about 5.5 per cent. The lesson taught by this experiment may be applied to the general use of the CO_2 determination.

It should be said in explanation that the furnace used in this experiment was a perfect one and produced an ideal mixture, else it would have been impossible to secure so high CO_2.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Loose Piston Caused Knocks

About six months ago a knock was detected in one of four vertical triple-expansion crank and flywheel pumping engines. Nearly every day since then it has been the duty of the engineer in charge to try his hand at getting this knock out of the engine, which occurred in the low-pressure cylinder on the upward stroke of the piston just as it passed the top centers.

It was at first thought that the piston was loose on the piston rod. The top bonnets were therefore removed, but the center-punch marks on the nut and piston rod were still opposite. Nearly every nut on the engine was tightened; the piston-rod packing was found in good condition; valve rods were lengthened and various amounts of compression were tried. When given a great amount of compression the knock shifted to the crank end when the crank was at an angle of about 10 degrees.

The cylinder was looked into again and a wrench put on the nut holding the piston in place and with a sledge the center-punch marks moved about ⅞ inch apart. When the pump was started up again the knock had disappeared. The amount taken up by the tightening of the nut was only 0.013 of an inch.

THOMAS H. BROCKMAN.

New Orleans, La.

How to Cut Packing

Most engineers contend that packing for steam or hot water should be cut diagonally and not allow the ends to touch when being fitted, but experience leads me to disagree.

If packing is cut obliquely, the ends will have more of a tendency to crowd away from the rod than if cut square. Furthermore, if the packing ring does not touch at the ends, the expansion of the packing is lost. When there is proper expansion of the packing it will be lengthwise of the stuffing box and the gland may be loosened and the stuffing box will really be fuller than when the packing was first placed in it. Packing which is cut short does not close the end space by the expansion, especially packings containing canvas or cloth. The spaces formed allow crosswise expansion of the ring of packing adjoining, and consequently allows more or less steam to pass.

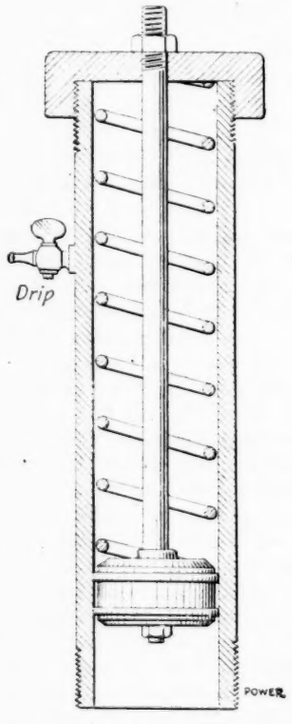
RAY GILBERT.

Virginville, W. Va.

Shock Absorber

Having read much about the destructive force of water hammer, I submit the accompanying illustration of a device which would eliminate a great deal of this trouble. The idea appears to be almost too simple to be new.

If instead of an air chamber my cushioning device were attached to the pump, there would always be a positive cushion.



SHOCK ABSORBER

A fireman blows down his boiler and recklessly turns the valve, thereby endangering the lives of all about him.

With my device no harm could result as the shock would be absorbed by the spring.

H. PREW.

Montreal, Can.

Pipe Fitting

It would seem that everyone should be well informed about pipe fitting, but one often finds some strange and wonderful arrangements. All piping should be run as direct as possible, avoiding unnecessary bends and making the required bends with a long radius where permissible. If an elbow and valve must be used an angle valve can take the place of the two fittings, thus avoiding extra pipe cutting. Elbows of 45 degrees should be more commonly employed as they reduce pipe friction.

Valves with male instead of female threads will often permit shorter connections and will save nipples and fitting besides having fewer leaky joints. Do not put a pipe with a long thread into a valve; a pipe thread as long as the thread in the nut on the valve is long enough if screwed in full length; if longer it will harm the valve.

In flanging pipe I have found that a good tight job may be easily and quickly made by heating the flange almost red hot and then quickly screwing it onto the pipe without using bars or wrenches, and cooling it off at once. Then cut off any projecting thread flush with the face of the flange and pull the pipe around the face of the flange. I have flanges put on a 6-inch pipe in this way that are constantly under 300 pounds cold-water pressure and they have never shown a leak.

Where there is room, I believe in bending the pipe to make the necessary angles; with very little experience good bends can be made by anyone. Where the bends are nicely made the job looks neater, has fewer joints in it to guard against leakage, leaves the pipes to expand and contract more freely and causes less friction. Piping up to about 1 inch can be bent cold; up to 4 inches it can be easily bent by being first heated in a forge and then bent by hand. For larger pipes one needs a gas or gasolene burner rigged up to go around the pipe so that it may be heated as desired. Then with one end of the pipe well anchored and a good pair of chain blocks on the other, one can bend any of the common sizes. The most common trouble is the buckling or flattening of the pipe while trying to make short bends. Probably a radius of seven times the diameter of the pipe is as short as can be well bent on standard pipe, but all heavy pipe will stand shorter bends.

Do not try to spring pipes into place if they do not fit. It will take less time to take them out and will make a better job.

Do not go at a job haphazard; think it over before starting and if the job is large or complicated it is better to take careful measurements and make a drawing of it before beginning; it will simplify the work.

EDWIN CONKLIN.

Twin Buttes, Ariz.

Inexpensive Heater

I have had very little hot-water returns in summer, and as I did not care to turn cold water into the boiler I made a heater from a galvanized tank 12 feet long, 4 feet wide and 20 inches high. It was so set that the exhaust pipe entered the end about 6 inches from the bottom. Fourteen 1-inch pipes were connected at each end by manifolds, and a float valve at the top keeps the tank supplied with water. A 1¼-inch pipe was connected at the bottom for draining purposes when cleaning was necessary.

The vacuum pump discharges into a receiver which has an automatic throttle valve for controlling the boiler-feed pump. A ¾-inch pipe was run from the tank to the receiver, and by slightly opening the valve from the tank I obtained sufficient water at about 190 degrees Fahrenheit, whereas before it did not reach 80 degrees at any time.

In winter, when the heating system is in use, I have more returns, therefore more exhaust steam is used and less goes through the tank, but I do not have to use so much water and it has more time to become heated. The total cost of this heater was approximately $22.

CLARENCE W. FASHBAUGH.

Fort Wayne, Ind.

Cause of Hot Bearings

If a bearing gets hot there must be some reason for it, and it is up to the engineer to find the cause and remove it.

The effect of dirty oil is to increase friction as the grit will cause the metals to wear quickly and cut in spots along the bearing. This bearing will then heat quickly.

Insufficient oil will increase friction because the film of oil between the rubbing surfaces is so diminished that the metals come in contact and heat.

When a bearing is out of line with the shaft or the pin, the load will have to be supported by a portion of the bearing; the load per square inch will be greater; this will force the film of oil out and increase the friction. The heating will be uniform at this point and intensify with an increase of load. A cure can sometimes be effected with pumicestone and oil, white lead, sulphur and oil.

I have used pumicestone and oil to good advantage, but these cures are used where the difference in alinement is slight. My method is to tighten the boxes snugly, start the engine slow and feed the pumicestone and oil mixture through a funnel to the bearing. Continue this feeding until the bearing or boxes get hot, but not enough to run the metal. The engine is then stopped and the boxes are washed clean with coal oil. The result is a finely polished pin and box. If the variations are too great, it will be necessary to resort to scraping.

When the boxes are too tight the heating will be gradual until the shaft has sufficiently expanded to grip them, when heat will be quickly generated.

If the boxes are too loose a succession of blows from the shaft or pin beat the oil from the bearing surface and from the metals making contact. A bearing that is too small will become overloaded at times, because the pressure per square inch of surface will be great enough to force the film of oil from between the metals.

Light bearings have caused engineers considerable worry. They may run nicely when the load is light and heat up when the load is increased. The only permanent cure is to increase the area of bearing or reduce the load.

H. R. BLESSING.

Philadelphia, Penn.

Boiler Room Repair

I used to have trouble with the through rods leaking on an 18-foot by 72-inch horizontal return-tubular boiler where the rods pass through the front head, as shown in Fig. 1.

These rods are held in place by a nut and washer on the inside and the outside of the front head. It was the practice whenever the rods leaked to loosen the outside nut and wind some asbestos wicking around the rod between the boiler head and the washer and then draw up on the nut. This would hold

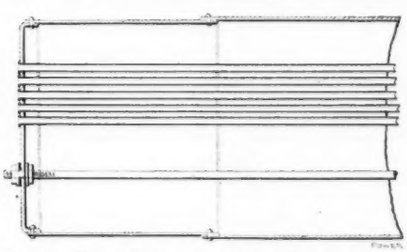


FIG. 1. RODS PASS THROUGH FRONT HEAD

tightly for a short time and then the job had to be done over again. I decided to try a ⅛-inch sheet-copper washer. It was put in place about five months ago and there has been no sign of a leak since. The copper washer was made to fit tightly over the rod.

When the top fire-door lining came down and the brickwork in the front of the boiler had to be repaired about once a month, I had a curved lining made, as shown in Fig. 2. This lining has been in use for about seven months and there is no sign of it again coming down. When it does I intend to have it replaced by an arch built of firebrick,

FIG. 2. CURVED LINING FOR TOP OF FIRE DOOR

thus doing away with the top iron lining.

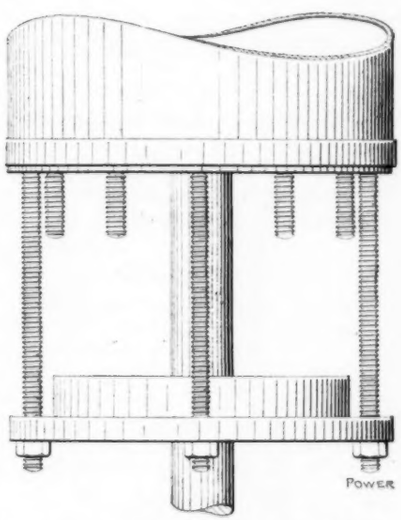
I would be pleased to hear what success the readers of POWER have had with this kind of arch.

H. B. JAHNKE.

Milwaukee, Wis.

Removing a Bottom Cylinder Head

Although it is on very rare occasions that the bottom cylinder head of a vertical engine has to be taken off, the time does come when such a thing is necessary.



HOW THE CYLINDER HEAD WAS REMOVED

There are many designs of vertical engines; hence, the methods which are used to do the work on some would not answer the requirements of others.

The method described here can be used on a number of differently designed vertical engines. The sketch plainly shows the idea. To use this method on old engines would make necessary the removal of four of the cylinder-head studs at four opposite points; then they would have to be replaced with four longer studs of a suitable length to permit the head to be lowered enough to enable the washers to gain easy access to the cylinder. After the long studs have been placed in position, four nuts should be run on them until the nuts touch the cylinder head. The head is

then lowered by unscrewing the four nuts; here care should be taken to have the head rest evenly on all of the nuts.

The four studs keep the head in position and no difficulty is encountered with the studs when replacing the head on the cylinder.

G. E. LAMBOURN.

McKeesport, Penn.

A Rope Brake for Measuring Power

The accompanying drawing shows a form of absorption dynamometer I devised and used for the measurement of small powers at high rotative speeds. A rope is placed over a pulley fixed to the shaft the power of which is to be measured. One end of the rope is fastened to a weight W, which rests on a platform scales, as shown. The other end is tied to a small pan to which weights w may be added. In operation the friction of the rope on the pulley tends to raise W and, therefore, the platform scales indicate less than this weight. The amount of the force tending to lift W obviously is the difference between its weight and the number of pounds recorded on the scales. The turning effort of the shaft in foot-pounds is then

$$(W - P)\ r - w\ r,$$

in which

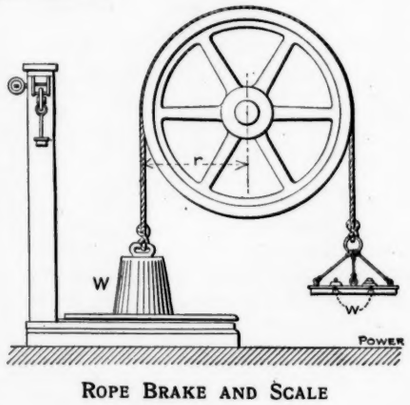
r is the radius to the center of the rope in feet, and

P is the scale reading.

The horsepower is

$$\frac{2\ \pi\ (W - P - w)\ r N}{33{,}000} = 0.00019\ (W - P - w)\ N$$

in which N is the number of revolutions per minute.



ROPE BRAKE AND SCALE

The turning effort may be controlled by varying the weights w, a small addition to which will materially increase the torque. An additional turn of the rope about the pulley will accomplish the same purpose.

This form of brake gives a very uniform resistance, there being practically none of the chattering so common to prony brakes, and it will give finer regulation than that type of dynamometer. It is superior to some of the other kinds of rope brakes with which I am familiar in that the stretch of the rope does not affect the torque. Its simplicity of construction will recommend it in cases where it is desired to measure the power of a small engine for a short time. It seems likely, too, that it would be suitable for larger powers if provision were made to prevent the rope from running off the pulley and to keep it cool.

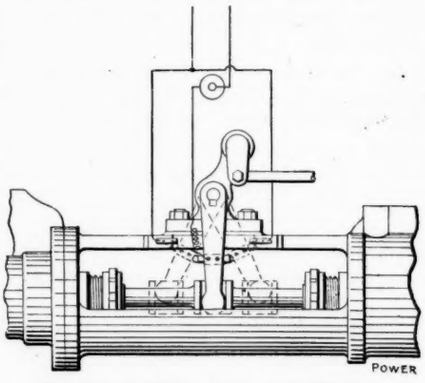
JULIAN C. SMALLWOOD.

Syracuse, N. Y.

Pump Telltale

In a large power plant two large boiler-feed pumps were set in the basement of the boiler house. I found an electrical telltale arrangement attached to both pumps as shown on the accompanying illustration.

On the rocker arm on one side of the



SHOWING CONTACTS AND WIRING

pump a contact piece was secured. At two points on either side of the rocker arm and at a distance within its reach two other contact pieces were placed, as shown. As the rocker arm swings, contact is made with first one stationary contact and then the other. These contacts light an incandescent lamp located where the fireman may see it and he knows that the pump which is out of his sight is operating properly.

R. S. WILHELM.

Indianapolis, Ind.

Scotch Yoke for Steam Engines

Why is it that the Scotch yoke is not used more on steam engines? It eliminates the effect of the angularity of the crank rod and permits of equal valve setting.

There must be reasons why the yoke is not used in preference to crossheads and crank rods. What are they?

Is the thrust upon the sliding surfaces of an engine using the Scotch yoke greater or less than it is on one employing a connecting rod of average length?

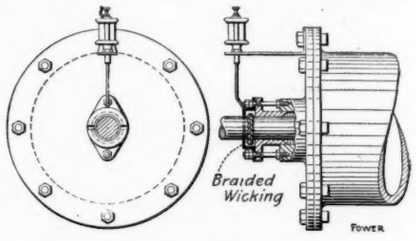
LLOYD V. BEETS.

Nashville, Tenn.

Piston Rod Swab

When I took charge of a certain plant some years ago the engine had metallic piston packing and required considerable oil on the piston rod. I tried a swab-holder which worked very well and made quite a saving in oil. The holder is shown herewith.

I took a piece of sheet copper and cut a hole in it large enough to clear the



SWAB ATTACHED TO STUFFING-BOX GLAND

piston about 1/16 inch all around. The outside of the holder is 1 inch wide and is cut through on one side so that it can be slipped over the piston rod. It is bent at the top and bottom so that it will clear the nuts on the gland. A small hole is provided at the top of the holder for a small pipe which leads from the oil cup to the swab. The swab was made of braided candle wick which fitted tightly around the piston rod.

Before using this device it required four cups of cylinder oil for a 10-hour run; with the swab one cup of oil is sufficient.

FRED LANGBEIN.

Port Clinton, O.

Efficiency Engineers

There is a growing class of individuals who succeed in fooling some of the people all the time. One of the latest additions to this fraternity is the efficiency engineer. When a plant is running along smoothly and paying a fair dividend, along comes the efficiency engineer. He ventures to suggest that he can cut the losses in half in a week and gets the contract. The process by which the saving is to be effected rests with the efficiency engineer. He is gifted with a divine inspiration the moment he enters the door which enables him to detect leaks which others who have specialized in power plants are unable to see. He finds that the fireman fires too frequently and admits too much cold air to the fires or that the engine could be run with less steam.

The owner, having hired this man, of course, immediately upon reading the report, suspects that his operating engineer is inexperienced and incompetent and that he has tolerated abuses which have cost immense sums of money. The operator finds it difficult to defend his position. The owner, being a nontechnical man, does not see the absurdity of the

situation and readily believes, when the appeal is made to his pocketbook, that the recommendations are sound.

It must, of course, be acknowledged that men who are experienced along certain lines are capable of correcting faults in places with which they are not familiar. Such men lend valuable service to both the owner and the operating engineer and their reputation is based on their achievements, but there are few indeed who are so broadly experienced that they can apply themselves with equal efficiency to all branches and successfully institute valuable changes in all sorts of engineering establishments. The class under consideration is composed of men who pretend to do this and who create false impressions and reap a good harvest because of them.

Success depends largely on opportunity and on ability, but principally on assurance. After all, the work is done by the "man behind the gun" and there are people who make a specialty of constructing guns. There are others who are experienced in making the ammunition and the method of firing is taught in the field. Just where does the stranger fit who has never seen a gun and who has never smelled powder?

ALFRED WILLIAMSON.

Bronxville, N. Y.

Simple Engine Stops

The devices shown in this article may help some young engineer to show his employer what he can do in the making of a safety stop for the old engine at practically no cost. The stops shown will give fair results in pipe sizes up to 3 inches in diameter; an old valve may be used which has been discarded on account of leakage, as a small leak will not matter when the valve is used as a safety stop.

In using an ordinary globe valve the threads on the stem must be removed. The valve shown in Fig. 1 works independently of the throttle valve. A clamp *B* is secured to the steam pipe and a lever *D* is pivoted at the points *C*. To close the valve in case of emergency pull the cord *A* and hook the ring over the hook *E*.

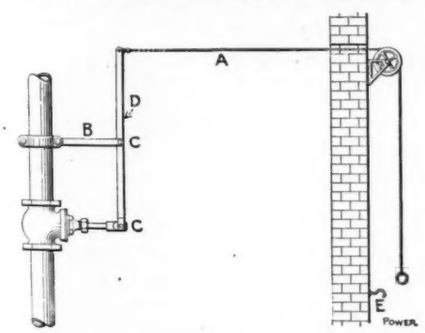


FIG. 1. AUXILIARY THROTTLE VALVE

If the valve were placed in a reverse position it could be closed by removing the ring from the pin, when the flow of steam will close the disk. This can be put in any handy place.

In Fig. 2 is shown a safety stop valve

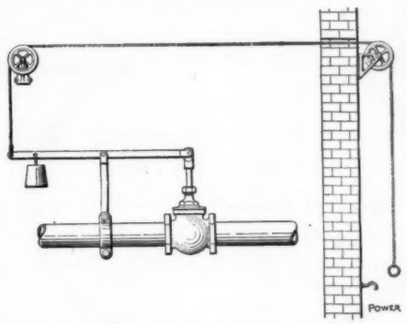


FIG. 2. VALVE IN HORIZONTAL PIPE

used on a horizontal pipe. The steam is below the disk which is held open by a weight independently of the steam pressure. To close it, the ring on the cord is pulled down and placed over the hook.

By reversing the position of the valve the stem can be held in the open position by placing the ring over the pin.

In Fig. 3 is shown an old idea slightly changed as to design; it can be used with

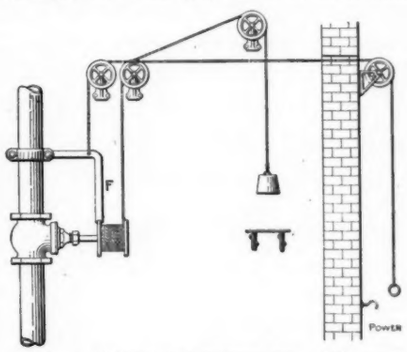


FIG. 3. VALVE OPERATED BY A WEIGHT

the steam pressure on either side of the disk. A grooved wooden pulley is made to fit on the valve stem upon which is fastened a metal disk. A slot is cut out of the flange which allows the stop *F* to fit into it and hold the valve open. The handle on the cord is placed at any desired point. A pull on it will raise the locking lever, which action will allow the weight to descend to a stop shelf, thus closing the valve.

TORONTO, CAN. JAMES E. NOBLE.

Fitting Brasses

Recently I had to replace the wristpin boxes on the high-pressure side of a 4200-horsepower vertical, cross-compound engine.

After starting up, the crank brasses ran very warm and slacking them off did no good. The engine was needed badly, and it meant eight or ten hours' work to again remove the brasses and pin.

Therefore we disconnected and plugged the telescope oiler on the back of the crosshead and in its stead put an improvised oiler in the duplicate hole in the front of the pin. This oiler consisted of a piece of 2-inch pipe about 10 inches long, and reduced to ½-inch pipe screwed into an ell, which was connected to the pin with a short nipple.

We then ground three cakes of Sapolio into a fine powder, and mixed about half a cupful to a gallon of cylinder oil, that had been warmed enough to flow readily, and fed it through the newly made oiler. The engine was timed at about 15 revolutions per minute, and in three hours it was put up to speed, using its own telescope oiler and oil system. It gave no more trouble.

G. B. GOUGSTREET.

Somerville, Mass.

Higher Wages

As regards higher wages and more strict license laws, I want to say that no amount of legislation alone will make a man fit to operate a power plant. He must be trained to fill such a responsible position.

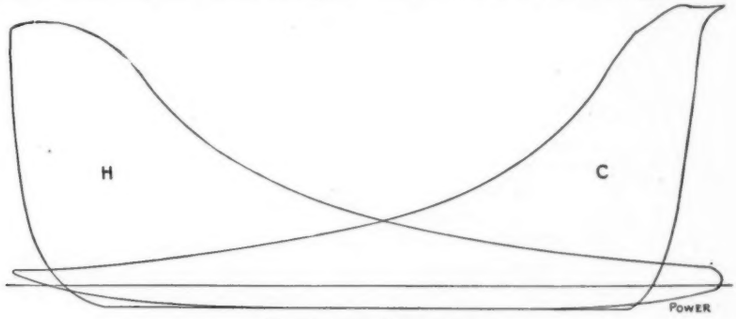
More uptodate education and less legislation is what is needed. If we make good in the plant, the company will make good in the pay envelop.

C. J. WRIGHT.

Alliance, O.

Diagram Advice Wanted

The accompanying diagrams were taken from a Wheelock engine. I would like to have some of the readers of POWER tell me what to do to remedy the appearance of the crank-end diagram at admission and cutoff.



DISTORTED DIAGRAM

W. H. BULLARD.

Goderich, Can.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Sizes of Turbine Steam and Exhaust Pipes

With reference to Mr. London's remarks on the above subject in POWER for July 25, I would say that I agree with much of what he says; and in my first letter on Mr. London's curves (POWER, March 28), I mentioned that I agreed that the curves were convenient and would save much calculation. I contend, however, as I contended then, that the curves are not correct in two respects:

Firstly, for any given weight of steam per minute, the curves give the same size of exhaust pipe for all terminal pressures from atmosphere to 24 inches vacuum, the velocity in the pipe varying from about 100 feet per second at atmospheric pressure to about 400 feet per second at 24 inches vacuum. For vacua above 24 inches, however, the pipe is made to increase in direct proportion to the specific volume of the steam, so that the velocity is always about 400 feet per second. This is not, I hold, scientific, nor yet is it correct from a commercial standpoint. There is no reason—academic or commercial—why an abrupt change of practice should take place at 24 inches vacuum. I believe that the velocity should be gradually reduced from the highest vacuum to atmospheric pressure; and the diagram, without increasing its complication, could be altered to give this.

Secondly, the curves give the same velocity for large-diameter as for small-diameter pipes. I hold that this should not be so, as the friction is less with large than with small pipes for the same fluid velocity. A velocity varying according to the size of the pipe could quite well be allowed for in the diagram without making it more complicated; all that is required is to alter the positions of the quadrants denoting the several diameters of pipe.

These were, and are, my points. I quite agree with Mr. London that a formula or diagram should not be excessively complicated; and that it may be (and usually is) impossible to allow for everything; but we ought, I contend, to allow for all important influencing factors, especially if these do not complicate the formula or diagram.

As regards Mr. London's remarks about the length of the exhaust pipe, this matter has already been dealt with in my last letter (POWER, June 27), and, if a bend be considered as equivalent to a certain length of pipe, the same reasoning will apply to bends.

It will be obvious from an inspection of my formula and Mr. London's diagram that the former could be put into graphic form for circular pipes and would be of exactly the same nature as is Mr. London's, and in use would be neither more nor less complicated.

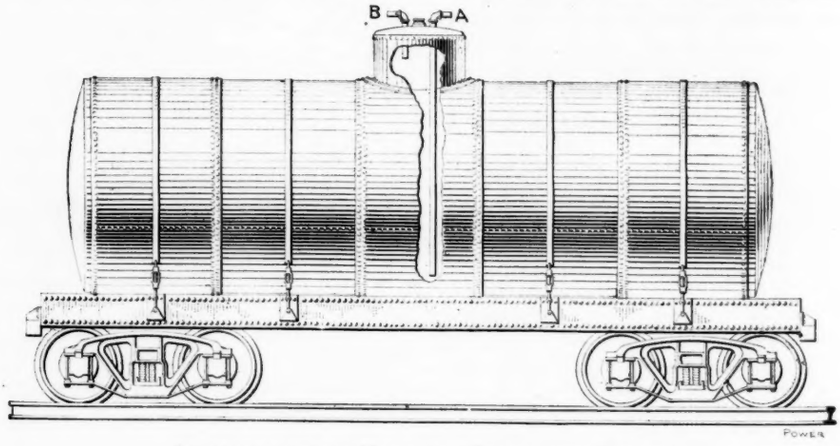
R. M. NEILSON.

Glasgow, Scotland.

Filling Oil Storage Tank

In answer to the request of W. W. Warner in the August 15 issue, I submit the accompanying illustration, showing how acid was forced from the car to the storage tank.

The outlet *A* was connected to the storage tank. The inlet *B*, used for filling the car, was connected to an air compressor. The compressor was then started, thus forcing the air into the top of the car, which in turn forced the acid out of the car through outlet *A*.



ARRANGEMENT OF TANK-CAR INLET AND OUTLET

In this manner the car was emptied without bringing the acid into contact with any pumping apparatus.

I have never tried this scheme with oil, but I think it would work.

CHARLES G. BUDER.

St. Louis, Mo.

Mr. Poarch's Diagrams

In the August 22 number, Mr. Poarch submitted a set of diagrams for criticism. We received so many letters discussing them that we are unable to print them all in full. Therefore, we offer the following synopses:

Mr. Hersey thinks that the cause of the engine pounding is due to lack of compression. His opinion in regard to the cause of the sloping exhaust line is that there is some obstruction in the exhaust ports or in the pipe or that the pipe is too small.

Mr. Knapp has the same point of view as Mr. Hersey, but states further that an excessively long exhaust pipe or one with a large number of bends in it would cause the sloping exhaust line. He believes that release takes place too late. This should be made earlier, as should also the point of compression by advancing the eccentric. Of course, this will cause earlier admission too, but this may be corrected by adjusting the link between the wristplate and the valve crank. That the expansion line does not fall below the atmospheric line may be due to the engine being overloaded.

Mr. Mason points out that with the load remaining the same an increase in the initial pressure would cause an earlier cutoff and hence a lower terminal pressure. The sloping exhaust line indicates to Mr. Mason that the exhaust ports open too late and the pound indicates that they also close too late. He suggests advancing the eccentric, not forgetting to adjust the steam valve after so doing if the engine is of the single-eccentric construction.

Mr. Cunningham writes that naturally if the engine runs satisfactorily noncon-

densing the valves must be reset in order to get similar satisfaction when running condensing. He also suggests changing the eccentric to secure an earlier exhaust opening and point of compression.

Mr. Rockwell states that Mr. Poarch must needs put on another eccentric so as to have the exhaust valves separately controlled, else when the single eccentric is adjusted for sufficiently early release the lead will be excessive. It is excessive lead which in Mr. Rockwell's opinion causes the pound when the engine is running condensing.

Mr. Prescott in a careful analysis of the diagrams reaches the same conclusion, that the point of release should be advanced, also the point of compression.

Mr. Gagnier thinks that the diagrams indicate leakage through the steam valves or reëvaporation in the cylinder. He suggests checking up the diagrams by comparing them with an ideal diagram having the same point of cutoff. Both Mr. Gagnier and Mr. Dickson, whose letter completes the number of letters received, suggest earlier release and point of compression.—[EDITORS.]

Value of CO_2 Recorder

Recently I have read several articles in POWER about the value of the CO_2 recorder. It seems to me that there is a good deal to say on both sides of the question. Certainly an accurate determination of the CO_2 in the stack gases from a boiler, together with a record of the temperature of the escaping gases, will show whether the fuel is being burned economically or not. High CO_2 means low excess air; with low excess air one is not using heat that should go to the water to raise the temperature of a large weight of cold air.

As for Mr. Vassar's statement that it is not possible to get an average sample by ordinary means, it has been my experience that with a ½-inch pipe, closed at the inner end and perforated with 1/16-inch holes extending across the last pass of the boiler, a couple of feet below the breeching of the stack, uniform and satisfactory results can be obtained. In this connection I disagree with Mr. Uehling's statement that the ordinary method of sampling by water displacement does not give an average sample. Under ordinary conditions, the variation in draft is comparatively small. As for the variation in the flow of water, I am sure that a measurement taken at the beginning and at the end of a run would show an error due to changes in the rate of flow of the water less than the error of the Orsat apparatus.

I believe that an analysis of the flue gas is of value in showing whether the fuel is being burned economically; that a continuous record is better than an average analysis, and that the sample can be taken satisfactorily. The trouble with the whole problem is this: Unless you have laboratory conditions under which to use your instrument, in addition to a skilled man to apply the results obtained, it is very difficult to obtain any results. I have had some slight experience with CO_2 recorders used in this vicinity, and it has been my observation that, while they were good enough in theory, practical difficulties, both mechanical and those due to the use of the available water, caused them to be very uncertain in their action.

J. F. MOWAT.

Joliet, Ill.

In reply to Mr. Uehling's letter in the issue of August 15 on the value of the CO_2 recorder, I wish to quote two of his statements, one from that letter and the other from an earlier one by him on the same subject. In separating these statements from the context I do not feel that Mr. Uehling is being treated unjustly as the statements are quite definite and are in no way modified by the context.

June 13: "In all cases high or low CO_2 means high or low efficiency....."

August 15: "CO_2 by itself is not claimed to be and, in the nature of things, cannot be a measure of efficiency....."

Enough said.

H. S. VASSAR.

Bloomfield, N. J.

Mr. Fryant's Diagram

From a study of Mr. Fryant's diagram, I believe that he will find that his trouble lies in a leakage past the piston as the first part of the expansion line is almost parallel to the admission line.

The leak may be due to a bad cylinder casting or a bad score in the cylinder wall; if it is a score, it is only a short one.

P. F. ROBNETT.

Kinmundy, Ill.

The indicator diagram on page 256 of the August 15 issue was probably taken from a low-speed engine of the Corliss type and at a very light load, the cutoff being at about 5.5 per cent. of the stroke. There appears to be a leak into the cylinder past the steam valve as, for the point of cutoff shown, the expansion line holds up too much at the end of the stroke, more than would be accounted for by reëvaporation.

If the engine is blocked in its position just after the start of the stroke, the steam valve dropped shut and the corresponding indicator cock left open, opening the throttle valve will probably show quite a blast of steam out of the indicator cock.

The writer once took some similar diagrams from a Rollins engine which has a gridiron cutoff valve on a vertical seat. The valve in seating carried by its proper position so that steam leaked past the back edges.

C. H. CHASE.

Stoneham, Mass.

In regard to the diagram submitted by Mr. Fryant in the August 15 issue, it is my opinion that the trouble is due to a partial closing of the valve as a result of lost motion, probably between the valve and valve stem.

H. W. APPLETON.

Sturbridge, Mass.

Bleeding Receiver to Heat Feed Water

Referring to the article in POWER for August 8, "Bleeding Receiver to Heat Feed Water," the writer thinks the reasoning is somewhat misleading as the statement is made that 903 B.t.u. would be available for evaporation. The principal medium for heating the feed water is the latent heat of the steam, since it is the condensing of the steam in the heater which heats the feed water.

The latent heat of steam at 24 pounds absolute is 953.5 B.t.u. Neglecting the radiation losses, this is the amount of heat which will be absorbed by the feed water for every pound of steam condensed.

Another point to be considered is that in order that the amount of work done by the high-pressure cylinder may remain constant the back pressure on this cylinder must increase, since to admit more steam the cutoff must take place later. This means that the receiver pressure must be increased and consequently the latent heat of the receiver steam will be reduced. In order to predetermine what the receiver pressure will be we would have a complicated problem to solve. There will probably not be much of an error made when this rise in pressure is neglected if we assume that only the latent heat of the receiver steam goes to increase the feed-water temperature.

If we assume that the engine will use 15 pounds of steam per indicated horsepower per hour, it will require

$15 \times 670 = 10{,}050$ *pounds per hour*

before the heater is installed.

Heat required to evaporate 25,500 pounds of water, or that needed for the 850-horsepower boiler, from a feed-water temperature of 100 degrees to steam at 155 pounds absolute =

$$25{,}500\ (1194 - 67.97) = 28{,}713{,}756$$

B.t.u.

Of course, the condensed steam from the heater would be trapped to the hotwell. To simplify the problem we may consider that the extra amount of condensation due to raising the feed water to 210 degrees does not mingle with the feed water in the hotwell.

Let x = additional steam, which will have to be admitted to the engine, and

let y = steam condensed in the heater to raise the feed water from 100 to 210 degrees.

If the engine is balanced, the steam which is drawn from the receiver will have done one-half of its work and

$$x = \tfrac{1}{2}\, y$$

The total amount of feed water which must be raised from 100 to 210 degrees will be

$$25{,}500 + x - y$$

y is negative because this amount of condensed steam will have a temperature due to the pressure in the receiver and, therefore, will not have to have its temperature raised. This is the reason why it was assumed that y did not mingle with the other water in the hotwell. Now we have

$$(25{,}500 + x - y)\ (178 - 67.97) = 933.5y$$

Substituting the value for x in this equation and solving, we find $x = 1391$ and $y = 2782$.

In order to admit this additional amount of steam to the engine the cutoff must be increased by about 14 per cent., neglecting clearance, and it should be ascertained whether or not this can be done before it is decided to install a heater.

The heat given to the feed water equals

$$953.5 \times 2782 = 2{,}652{,}637\ B.t.u.$$

Heat required to evaporate 1391 pounds of water from 210 degrees to 155 pounds absolute equals

$$1391\ (1194 - 178) = 1{,}413{,}256$$

which means a saving of

$$2{,}652{,}637 - 1{,}413{,}256 = 1{,}239{,}381\ B.t.u.$$

or

$$\frac{123{,}981}{28{,}713{,}765} = 4.31\ per\ cent.$$

GEORGE M. PEEK.

St. Louis, Mo.

We were much interested in reading the article on "Bleeding Receiver to Heat Feed Water" in the issue of August 8, because it recalls certain happenings of long ago.

Twenty years ago, when the open-heater business was young and the Webster feed-water heater was one of the thriving infants, power-plant owners were hungry for anything that looked like economy, but they were all "from Missouri"—they had to be shown.

We remember one case, in a New England mill. We tried to interest the mechanical engineer in our apparatus to effect economy by heating his feed water. We were told that it would be impossible for us to aid him, for he was runing the plant condensing, with a compound engine, and could furnish no exhaust steam for an open heater.

Instead of being discouraged, our then youthful spirit rose to the occasion and "Necessity" became "the mother of invention"—we needed that order.

We had theorized along the lines of the article and felt sure that we could save 4 or 5 per cent. of fuel, but we had "doubting Thomases" to convince, and the most convincing argument we used was that we would take back our heater, and pay for the piping changes, too, if we failed.

The owner was perfectly willing to pay our price if we made good.

We did not fail. The theoretical savings were amply borne out by the actual results, and what to us was then a new principle was established.

It seemed so novel that its inventor, Warren Webster, applied for a patent; but the Patent Office examiners at first refused it, on the ground that it was an impracticable invention—something like perpetual motion. When confronted, however, with actual proofs of success, the patent was allowed.

We made use of the idea in a number of suitable cases during the next decade or so, and still use it. We are under the impression that we were the first and only ones to use it up till two years ago, unless someone unwittingly infringed our patents.

The patent expired about two years ago, however, and the public is free to use it. It is a good idea and our experience bears out your theory. The savings have amounted to from 3 to 6 per cent., depending upon conditions.

WARREN WEBSTER & CO.

Camden, N. J.

Gage Glass and Water Level

In reply to a question by W. L. B. in the issue of July 25, it was stated that a gage glass in good order would show the true water level in the boiler.

This is not exactly the case because the water inside the boiler, being expanded by the high temperature, is balanced by a slightly lower column of cooler water in the gage glass and its connections.

This is easily demonstrated by blowing out the water column until it becomes hot, when the water level will be from ½ to ¾ inch higher than when the column was cool.

ROY W. LYMAN.

Ware, Mass.

Gage Glasses

In the issue of August 8, Mr. Williams refers to gage glasses and washers, and says: "The washer should be placed in the bottom of the nut." I would like to have him explain a little more fully what he means, as I am carrying high pressure and have considerable trouble with my gage glasses.

T. BOND.

San Diego, Cal.

Making Corliss Valve Gear Noiseless

Having read C. R. McGahey's article in the August 15 POWER on silencing valve gears, I tried the same stunt, drilling holes in the crab claws and plugging them with rawhide, but I got no results. The crab claws were of steel while his might have been bronze.

I have found the most successful way to silence the ring in a steel crab claw is to remove the case-hardened tail piece and substitute black fiber tail pieces. The black will wear much longer than the red.

In ordering the fiber try to get it as near the thickness of the steel tail piece as possible. I usually make about a dozen at a time, but a pair will last from six to eight weeks on 36x42-inch cylinders. Care should be taken in fitting them or they will throw the cutoff adjustments out. The surest way is to apply the indicator after putting on a new set, and the result is well worth the trouble of renewing them every month.

H. J. MISTELE.

Milwaukee, Wis.

Heat Units Required to Evaporate Moisture in Coal

Referring to Mr. Blumenstein's article on "Heat Units Required to Evaporate Moisture in Coal," there are two kinds of moisture in a shipment of coal, namely, moisture in "crystalline" form, which is inherent with the coal when mined, and the "surface moisture," which is entirely superficial and becomes mixed with the coal in washing, sometimes in transit during rain and snow storms, and again by sprinkling before firing.

The former, which may be from 0.5 to 25 per cent. of the total weight, is usually bought and paid for as coal. Furthermore, this moisture reduces the evaporation both by cutting down the amount of combustible and by heat being required to evaporate this moisture.

The surface moisture, which may vary from zero to about 4 per cent. of the total weight, is something that can, to a large extent, be eliminated, and when contracts are made it is well to have it stipulated that the coal must not contain more than a certain percentage of moisture.

In conclusion it may be said that moisture in coal is a dead loss to the consumer, and can in no way be made to help out a contract where the cost of evaporation and efficiency are at stake, unless it be in that more imaginative way where the hydrogen formed from the decomposition of the moisture is made to yield its heat to the water in "that more efficient manner."

M. O. HORNING.

Swissvale, Penn.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Bearing Pressures in Gas Engines*

By G. W. Lewis and A. G. Kessler

The accompanying charts and tables show the average values of the maximum bearing pressures in American stationary gas engines as computed from data obtained from the manufacturers.

Maximum Explosion Pressures in Pounds per Square Inch of Piston Face

Gasolene Engines

The average compression pressure of gasolene stationary engines was found to range from 60 to 75 pounds gage, which gives a corresponding maximum explosion pressure of from 250 to 300 pounds per square inch.

Producer Gas Engines

In engines using producer gas (anthracite), the compression pressure was found to range from 90 to 175 pounds gage, and the maximum explosion pressure from 300 to 400 pounds.

Natural Gas Engines

For engines using natural gas, the compression pressure varied from 80 to 150 pounds gage, and the maximum explosion pressure from 300 to 450 pounds per square inch of piston face.

The above values were furnished by manufacturers of the different types of engines.

In the accompanying tables the bearing pressures have been computed from explosion pressures of 250, 300, 350 and 400 pounds, and on the assumption that the explosion occurs when the crank is at the head-end dead center.

Crank-shaft Bearing Pressure

Horizontal Single-cylinder Engines

From Chart I the average relation between the cylinder diameter and the bearing diameter of the crank pin is determined. From Chart 2 the bearing length of the crank pin is determined in terms of the bearing diameter. Using the data obtained from Charts 1 and 2, Table 1 was computed; it gives the average maximum unit bearing pressures for cylinder diameters of 4, 8, 12, 16, and 20 inches, on the assumption of maximum explosion pressures of 250, 300, 350 and 400 pounds per square inch of piston face.

TABLE I. FOR HORIZONTAL ENGINES

D	4	8	12	16	20	Assumed
D_{cp}	$1\frac{1}{2}$	$3\frac{1}{4}$	$4\frac{3}{4}$	$6\frac{3}{8}$	$8\frac{1}{4}$	From chart 1
L_{cp}	$1\frac{5}{8}$	$3\frac{1}{4}$	$4\frac{7}{8}$	$6\frac{5}{16}$	$8\frac{3}{8}$	From chart 2
A_{cp}	2.44	10.15	23.2	41.75	68	$D_{cp} \times L_{cp} = A_{cp}$
P_m	—250—					Assumed
K_{cp}	1290	1240	1220	1210	1150	From equation A
P_m	—300—					Assumed
K_{cp}	1550	1485	1450	1450	1390	From equation A
P_m	—350—					Assumed
K_{cp}	1800	1730	1710	1690	1620	From equation A
P_m	—400—					Assumed
K_{cp}	2060	1980	1950	1930	1850	From equation A

D = Cylinder diameter in inches.
P_m = Maximum explosion pressure in pounds per square inch of piston face.
D_{cp} = Bearing diameter of crank pin in inches.
L_{cp} = Bearing length of crank pin in inches.
K_{cp} = Maximum unit bearing pressure in pounds per square inch.
$A_{cp} = D_{cp} \times L_{cp}$, in square inches.

$$\text{Maximum } K_{cp} = \frac{\pi D^2}{4} \cdot P_m \div (D_{cp} \times L_{cp}). \qquad \text{(A)}$$

*Copyrighted, by G. W. Lewis, 1911.

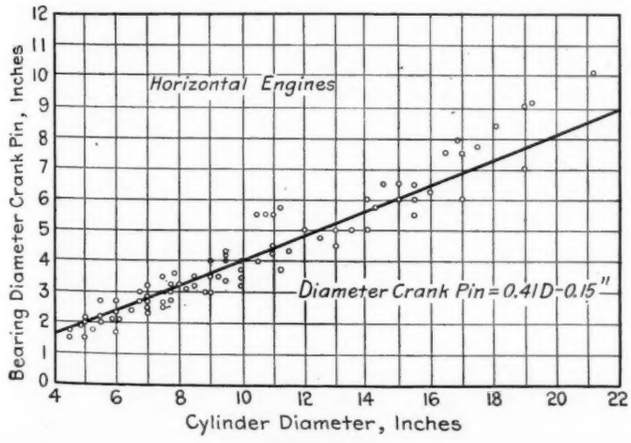


CHART 1

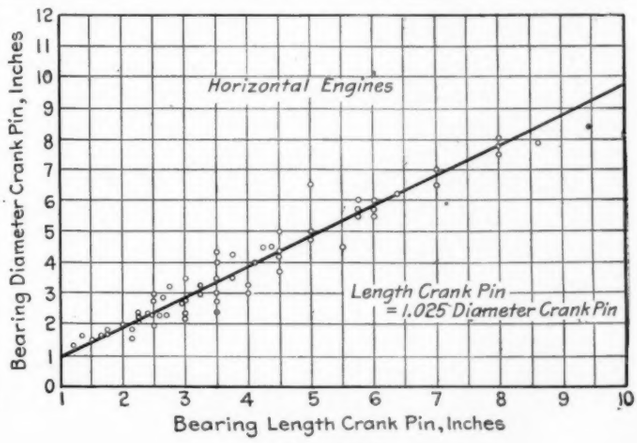

Horizontal Engines
Length Crank Pin = 1.025 Diameter Crank Pin
Bearing Diameter Crank Pin, Inches
Bearing Length Crank Pin, Inches

CHART 2

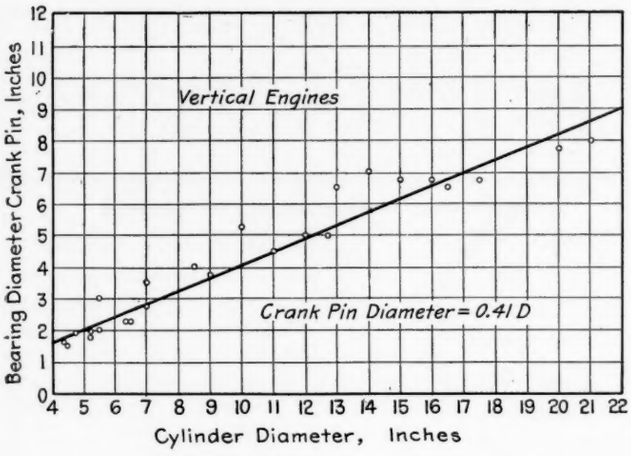


CHART 3

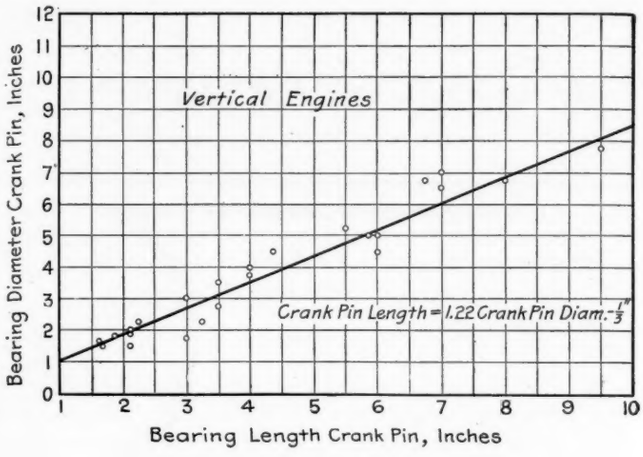

Vertical Engines
Crank Pin Length = 1.22 Crank Pin Diam. - 1/2"
Bearing Diameter Crank Pin, Inches
Bearing Length Crank Pin, Inches

CHART 4

Vertical Single- and Multiple-cylinder Engines

Chart 3 gives the average relation between the cylinder diameter and the crank-pin diameter. Chart 4 gives the crank-pin diameter and the crank-pin length for vertical engines. From these Table 2 was computed, with the use of the same cylinder sizes and explosion pressures as in Table 1.

COMPARISON OF PRESSURES ON CRANK PINS

The comparison of the average maximum units of bearing pressures on the crank pins of vertical and horizontal engines is best shown by Chart 5. As can be seen, the pressures in the vertical engines are considerably less than those in the horizontal engines. In comparing the tables, it also will be noted that the increase of projected bearing area in the vertical-engine crank pin is accomplished by increasing the bearing length and not the diameter of crank pin, as increasing the latter would increase the circumferential speed.

The reason for making the unit bearing

TABLE II, FOR VERTICAL ENGINES

D	4	8	12	16	20	Assumed
D_{cp}	1⅝	3¼	4⅞	6½	8 3/16	From chart 3
L_{cp}	1⅝	3⅛	5⅛	7⅛	9⅛	From chart 4
A_{cp}	2.64	11.8	27.8	49.75	78.75	$D_{cp} \times L_{cp}$
P_m	—250—					Assumed
K_{cp}	1190	1065	1035	1015	995	From equation A
P_m	—300—					Assumed
K_{cp}	1430	1280	1240	1215	1200	From equation A
P_m	—350—					Assumed
K_{cp}	1660	1490	1440	1420	1400	From equation A
P_m	—400—					Assumed
K_{cp}	1920	1720	1660	1620	1600	From equation A

D = Cylinder diameter in inches.
P_m = Maximum explosion pressure in pounds per square inch of piston face.
D_{cp} = Bearing diameter of crank pin in inches.
L_{cp} = Bearing length of crank pin in inches.
K_{cp} = Maximum unit bearing pressure in pounds per square inch.
$A_{cp} = D_{cp} \times L_{cp}$, in square inches.

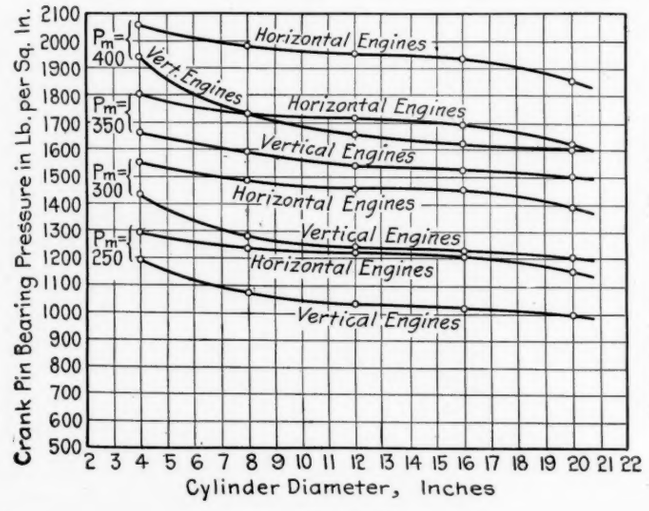


CHART 5

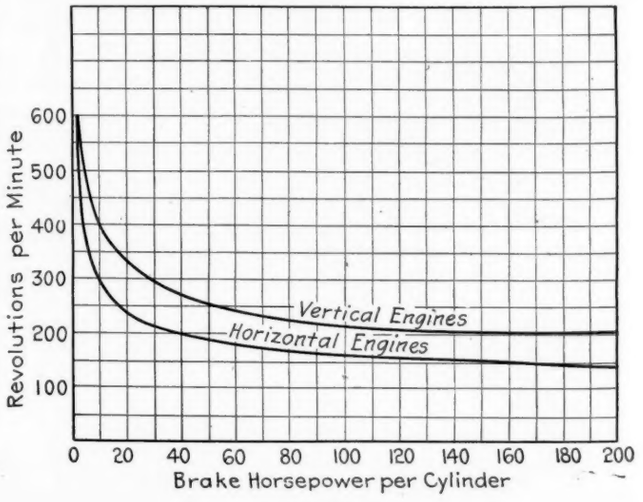


CHART 6

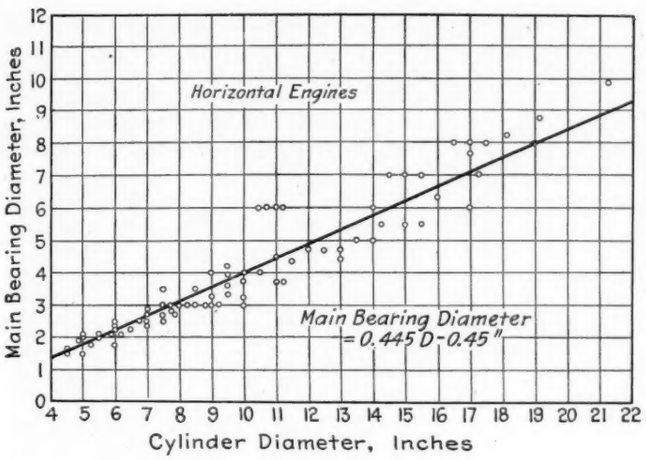


CHART 7

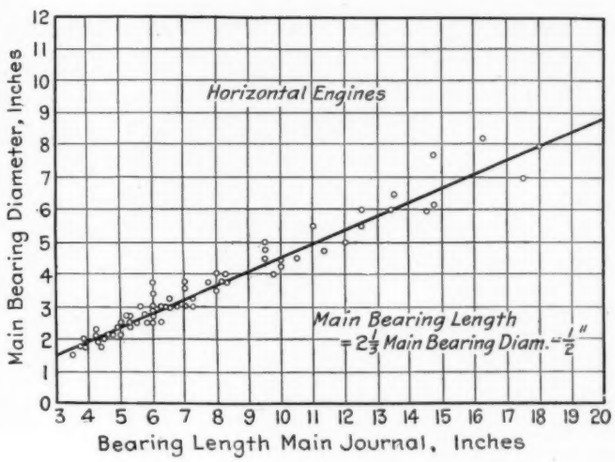

Horizontal Engines
Main Bearing Length
= 2⅓ Main Bearing Diam. − ½"
Main Bearing Diameter, Inches
Bearing Length Main Journal, Inches

CHART 8

pressure less in vertical than in horizontal engines is apparent from Chart 6, which shows the relation between the revolutions per minute and the brake horsepower.

FRICTION IN CRANK PINS

The work of friction in crank pins is about the same for both vertical and horizontal engines, as shown by the following tabulation, which is computed for one case from the following data:

	Horizontal	Vertical
D = cylinder diameter	12 inches	12 inches
D_{cp} = diameter of crank pin	4¾ inches	4⅞ inches
L_{cp} = length of crank pin	4⅞ inches	5⅛ inches
R.p.m.	200	250
Maximum explosion pressure	300	300 pounds per square inch of piston face
Mean pressure on piston	20	20 pounds per square inch of piston face
Maximum unit bearing pressure	1450	1240 pounds per square inch
(K_m) Maximum unit bearing pressure	98	81
(V) Circumferential speed in feet per second	4.15	5.3
Work of friction $V \times K_m$	407	429 foot-pounds per second

TABLE III, FOR HORIZONTAL ENGINES

D	4	8	12	16	20	Assumed
D_{mb}	1.3	3.1	4.85	6.6	8.4	From chart 7
L_{mb}	2.6	6.75	10.8	14.9	19.1	From chart 8
A_{mb}	3.4	20.9	52.5	98.5	160.5	$D_{mb} \times L_{mb}$
P_m	—250—					Assumed
K_{mb}	462	300	270	255	244	
P_m	—300—					Assumed
K_{mb}	553	360	324	307	293	
P_m	—350—					Assumed
K_{mb}	647	420	377	358	342	
P_m	—400—					Assumed
K_{mb}	738	503	430	408	391	

D = Cylinder diameter in inches.
D_{mb} = Main bearing diameter in inches.
L_{mb} = Main bearing length in inches.
A_{mb} = Projected area main bearing (one) = $D_{mb} \times L_{mb}$.
P_m = Maximum explosion pressure in pounds per square inch of piston face.
K_{mb} = Maximum unit bearing pressure in pounds per square inch, on the assumption that explosion occurs on the dead center.

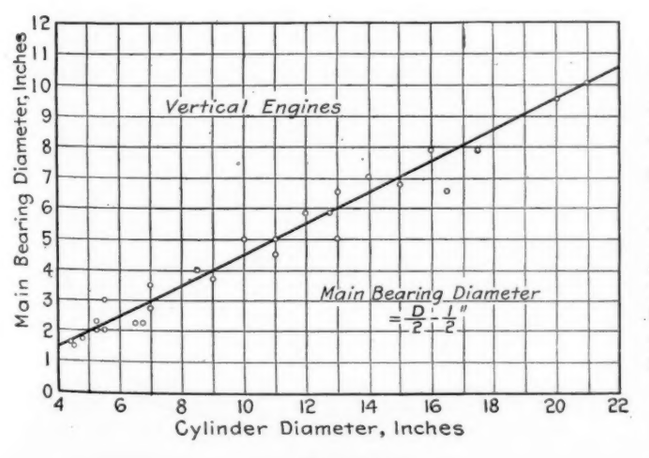


CHART 9

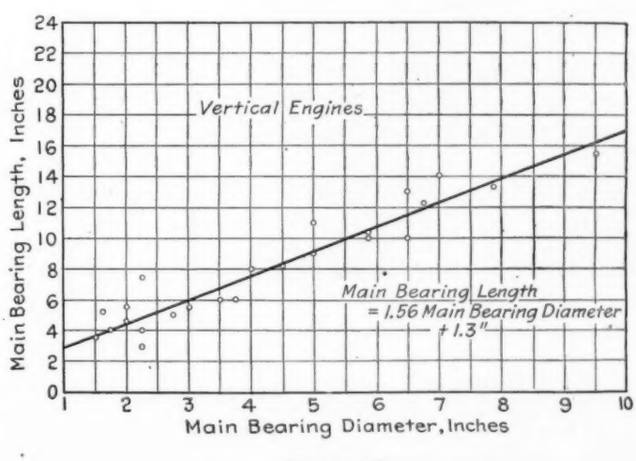


CHART 10

Average Maximum Unit Bearing Pressure on Main Bearings

Horizontal Single-cylinder Engines

Chart 7 gives the average relation between the cylinder diameter and the main-bearing diameter. Chart 8 shows the relation between the main-bearing length and the main-bearing diameter. On the assumption that each of the two main bearings takes one-half the explosion load of the engines, and without the flywheel weights, Table 3 was computed.

Vertical Single- and Multiple-cylinder Engines

From Charts 9 and 10, Table 4 was computed, showing the average maximum unit bearing pressure on the main bearings of vertical engines. In multiple-cylinder engines, the outside or end bearings next to the flywheels are often made considerably longer, from 1.5 to 1.75 times the lengths given in Table 4.

Average Maximum Unit Bearing Pressure on Piston or Wristpin

Horizontal Single-cylinder Engines

Table 5 was computed from data obtained from curves giving the relations between cylinder diameter, wristpin diameter, and wristpin bearing length; the relations are expressed in equations B and C, Table 5.

Vertical Single- and Multi-cylinder

Table 6 was computed in the same manner as Table 5 from equations D and E. These show the relations between average cylinder diameters, wristpin diameters, and wristpin bearing lengths for vertical engines.

TABLE IV, FOR VERTICAL ENGINES

D	4	8	12	16	20	Assumed
D_{mb}	1½	3½	5½	7½	9½	From chart 9
L_{mb}	3½	6¾	10	13	16	From chart 10
A_{mb}	5.25	23.6	55	97.5	152	$D_{mb} \times L_{mb}$
P_m	—250—					Assumed
K_{mb}	300	267	258	258	258	
P_m	—300—					Assumed
K_{mb}	359	320	310	310	310	
P_m	—350—					Assumed
K_{mb}	415	373	360	360	360	
P_m	—400—					Assumed
K_{mb}	481	414	414	414	414	

D = Cylinder diameter in inches.
D_{mb} = Bearing diameter of main bearing in inches.
L_{mb} = Bearing length of main bearing in inches.
$A_{mb} = D_{mb} \times L_{mb}$.
P_m = Maximum explosion pressure in pounds per square inch of piston face.

TABLE V, FOR HORIZONTAL ENGINES

D	4	8	12	16	20	
D_{wp}	0.93	1.62	2.76	4.36	6.42	From equation B
L_{wp}	1.6	2.8	4.77	7.52	11.15	From equation C
A_{wp}	1.49	4.54	1.32	32.8	71.5	$D_{wp} \times L_{wp}$
P_m	—250—					Assumed
K_{wp}	2100	2760	2145	1530	1100	
P_m	—300—					Assumed
K_{wp}	2530	3230	2570	1840	1320	
P_m	—350—					Assumed
K_{wp}	2950	3880	3000	2150	1540	
P_m	—400—					Assumed
K_{wp}	3370	4425	3430	2455	1.760	

D = Cylinder diameter in inches.
D_{wp} = Bearing diameter of piston pin in inches.
L_{wp} = Bearing length of piston pin in inches.
A_{wp} = Projected area of piston pin in square inches.
P_m = Maximum unit explosion pressure.
K_{wp} = Maximum unit bearing pressure in pounds per square inch.
$D_{wp} = 0.0143\ D^2 + 0.7$ inch. (B)
$L_{wp} = 1.75\ D_{wp}$. (C)

An Operator's View of the Diesel Engine

By William F. Caton

Noticing considerable discussion lately of the Diesel engine from the standpoint of the operator, I am encouraged to put forth a few points based on my own experience. This type of engine gives as little trouble as any piece of power machinery I have ever had anything to do with. If all valves are kept tight and the pistons and valves kept free from carbon, the Diesel engine will work like a clock from starting to stopping time.

It seems to me, however, that the builders have made a serious mistake in advertising these engines to be able to give good service with the cheapest of help for operators. I have found that all internal-combustion engines need just as good mechanics to operate and maintain them successfully as do steam engines.

The general run of operators claim that the Diesel engine will work the best and consume the least oil per unit of output when working at about 75 per cent. of the builder's rating, and I have noticed that they will smoke when overloaded or run on very light loads.

One very great operating advantage about this engine is the absence of batteries, magnetos and spark plugs to bother with; these parts constitute one of the great drawbacks of most internal-combustion engines. A feature of the Diesel engine which operators dislike, however, is the splash lubrication, which makes such hard work repairing bearings, cranks, piston pins, etc. No matter how thoroughly one tries to clean the parts in the crank case there is always slush dripping on your head and shoulders. As this is true of all splash-lubricated engines, however, it is not fair to consider it as peculiar to the Diesel engine,

and I do not mean to intimate that it should be so considered.

In a plant of six engines, driving generators which deliver a total of 900 kilowatts, I find that four men are required to operate the engines, compressors and switchboard.

I would like to see other operators give their views regarding this type of engine.

Power Transmission on Oil Power Vessels

By John F. Wentworth

In the Power of August 15 there was an editorial on this subject in which ideas were expressed which differ far from those which I have been working on for a long time.

First, however, I wish to say that I can see no legitimate excuse for the use of gears between the propeller and the driving engine. If my memory does not fail me, the report of the British commission which met to pass upon the installation of turbines in the "Mauretania" and her sister ship reported that the efficiency gain would be about one-tenth of 1 per cent. With this slight gain all sorts of mechanical contraptions are proposed to enable the turbine to stay in the marine field.

Now, coming to the engine question, I wish to protest against Power's ideas on the marine oil engine. I claim to be the "original" marine oil-engine man. In substantiation of this claim I refer the reader to my article on the "Efficiency of the Marine Oil Engine," which was published in *Marine Engineering* of December, 1904. The ideas expressed at that time were opposed by such men as Lewis Nixon and numerous smaller lights who stood out for the gas producer for future achievements in the field of marine engineering. The gas-producer vessel of any size has yet to show up but the oil engine, according to press reports, is now being installed in vessels larger than the one which I took for a concrete example in 1904. Referring to the editorial of August 15, I object to the charge that "inherent lack of flexibility" is "characteristic of all types of internal-combustion engines." The Sargent gas engine, in which the proportion of air to fuel is kept constant, is flexible as far as efficiency at all loads is concerned. The use of an unnecessary amount of air with the fuel is a cause of lessened efficiency. If this "lack of inherent flexibility" is meant to apply to the Diesel engine I will heartily agree with Power. It is in order to overcome some of the major drawbacks of the Diesel engine that I have spent much time and money, trying to produce an engine which shall be the last word in the internal-combustion engine. I hope before long to have the opportunity to explain in detail some of my ideas to the readers of Power and to invite criticism and discussion.

Relative to the proposition to equip vessels with an oil engine, a generator and a motor, I fail to see the advantage. The Diesel engine at best has an efficiency of 30 per cent., and the mechanical efficiency of the generator and motor will be about 90 per cent. each, bringing the overall efficiency down to about 24 per cent. In order to equip a vessel needing 1000 horsepower, the motor must be capable of 1000 horsepower, the generator over 1100 horsepower and the oil engine not far from 1250 horsepower. I should condemn such an arrangement as inefficient and unnecessarily expensive. It would in my opinion be far better to rely upon air starting and reversing than to go to such trouble and expense. On a vessel of any size at all the saving would easily pay for the engineer on watch to answer the bells, even if the force could be reduced by the use of the electric transmission gear. The main disadvantage of relying on compressed air is in the large bulk of air needed to enable an engine of large size to be manœuvered. There is also a possibility of the compressor going wrong and crippling the plant. One of the points I have been working on for the last few years is to overcome this defect. Owing to the patent situation, I do not feel free to give out details yet, but I am working on a substitute for compressed air which shall be as positive as air, capable of being stowed in a small fraction of the space which the air at the same pressure would take up, and more easily prepared than compressed air.

An engine using crude oil for a fuel and equipped with a method of governing similar to the Sargent principle as applied to gas engines, coupled with some compact means for stowage of compressed air would to my mind leave nothing to be desired in the marine-engine line. If I do not succeed in meeting these specifications, I hope someone will be fortunate enough to solve this important and interesting problem. I do not believe that it is necessary to harness the oil engine to a generator in order to secure a perfectly flexible and thoroughly reliable prime mover for vessels.

TABLE VI, FOR VERTICAL ENGINES

D	6	8	12	16	20	
D_{wp}	$1\frac{5}{8}$	$1\frac{7}{8}$	$2\frac{1}{2}$	$3\frac{3}{4}$	$4\frac{1}{2}$	Equation D
L_{wp}	$2\frac{7}{8}$	$3\frac{3}{8}$	$4\frac{1}{2}$	$6\frac{1}{8}$	$8\frac{1}{4}$	Equation E
A_{wp}	4.67	6.33	11.25	20.65	36.6	$D_{wp} \times L_{wp}$
P_m	—250—					Assumed
K_{wp}	1510	1990	2520	2430	2145	
P_m	—300—					Assumed
K_{wp}	1810	2380	3020	2920	2580	
P_m	—350—					Assumed
K_{wp}	2120	2780	3520	3410	3010	
P_m	—400—					Assumed
K_{wp}	2420	3190	4030	3900	3440	

D = Cylinder diameter in inches.
D_{wp} = Bearing diameter of piston pin.
L_{wp} = Bearing length of piston pin.
A_{wp} = Projected area of piston pin in square inches.
K_{wp} = Maximum unit bearing pressure in pounds per square inch.
P_m = Maximum unit explosion pressure.
$D_{wp} = 0.00795\ D^2 + 1\frac{3}{8}$ inches. (D)
$L_{wp} = 1.82\ D_{wp}$. (E)

[We cheerfully concede Mr. Wentworth's claim to pioneering honors and heartily wish that he may achieve the fullest measure of success. But we cannot withdraw the assertion that all internal-combustion engines are inherently inflexible until he or someone else succeeds in building one that is not. Flexibility, however, is a matter of speed change and starting ability, not efficiency, and we have yet to hear of a self-starting gas or oil engine or one that accelerates rapidly with full load.

Mr. Wentworth's criticism of the electric transmission is, of course, justified, but the disadvantages which he cites are well known and were referred to in our editorial. The whole question reduces to this: Is it better to continue using compressed air for starting and put up with inefficient propeller speeds and (sometimes) engine speeds, or to interpose some form of flexible transmission between the engine and propeller and thereby obtain both quick propeller control and maximum propeller and engine efficiencies?—Editor.]

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Water Hammer in Steam Pipes

What causes water hammer in a steam pipe? Explain the theory.

W. H. S.

Water hammer is caused by the sudden arrest of plugs of water which are got into rapid movement in the pipe by conditions which bring about a different pressure on the opposite sides of the plug, as, for instance, when the plug shuts off the communication between the boiler and has boiler pressure on one side and a reduced pressure due to condensation, the drawing off of the steam or both upon the other.

Annular and Spur Gears

The pitch diameter of an annular gear is 36 inches. The spur gear meshing with it is 8 pitch and has 24 teeth. How many revolutions must it make to turn the annular gear 13 times?

B. C. H.

An 8-pitch gear with 24 teeth has a pitch diameter of 3 inches and in one revolution it will move the larger gear $\frac{3}{36} = \frac{1}{12}$ of one revolution. To move it through 13 revolutions the small gear will have to revolve $\frac{13}{\frac{1}{12}} = 156$ times.

Discharge Temperature for Ammonia

We have a 9½x20-inch ammonia compressor running 70 revolutions per minute and the discharge pipe is so hot that a drop of water put on it will boil immediately. Is the pipe too hot and does it hurt the ammonia?

T. L. D.

The proper discharge temperature for an ammonia compressor operating between 15 and 185 pounds gage pressure is about 250 degrees Fahrenheit. This temperature is not too high for continuous operation. If desired, the temperature of the discharge can be reduced by slightly increasing the opening of the expansion valves, so that a small amount of liquid ammonia is returned to the compressor.

Cross Compound Engine Valve Setting

How are the valves set on a cross-compound engine? I understand how to do it with a simple engine.

C. A. L.

In a cross-compound engine the valves are set for each cylinder as though they were on separate engines. If the valve gear is direct, the eccentric will lead the crank 90 degrees plus enough to take up the lap and lead. If the valve gear is indirect the eccentric will be 90 degrees behind the crank, minus advance enough to move the valve through the lap and lead.

Safety Valve and Grate Area

With 24 square feet of grate, burning 12 pounds of coal per hour on each square foot and each pound of coal evaporating 10 pounds of water into steam at 100 pounds gage pressure, what area of safety valve will be required?

H. D. H.

There would be burned

$$12 \times 24 = 288 \text{ } \textit{pounds}$$

of coal per hour, and if each pound of coal evaporated 10 pounds of water there would be

$$288 \times 10 = 2880 \text{ } \textit{pounds}$$

of steam made per hour or

$$\frac{2880}{3600} = 0.8 \text{ } \textit{pounds per second}$$

The evaporation per square foot of grate surface per second would be

$$0.8 \div 24 = 0.033$$

Applying the Massachusetts formula for the area of safety valves

$$A = \frac{W \times 70 \times 11}{P}$$

in which

A = Area of the valve in square inches for each square foot of grate surface;

W = Pounds of water evaporated per second per square foot of grate surface;

P = Absolute pressure per square inch at which the valve is set to blow.

$$\frac{0.033 \times 70 \times 11}{115} = 0.22$$

$$0.22 \times 24 = 5.28 \text{ } \textit{square inches}$$

of safety valve. The nearest commercial size of valve will have a diameter of 3 inches.

Centrifugal Force

How is the centrifugal force of a revolving body found?

A. J. L.

To find the centrifugal force exerted by a revolving body multiply the weight in pounds by 0.00017, by the diameter in feet of the circle in which the body revolves, and by the square of the number of revolutions per minute. The product will be the centrifugal force in pounds.

Flywheel Diameter and Rim Velocity

If the linear velocity of the rim of a flywheel is limited to a mile a minute, how many revolutions per minute are allowable if the wheel is 9½ feet in diameter?

B. H. C.

For a rim speed of a mile per minute the number of revolutions is found by dividing 1681 by the diameter of the wheel in feet:

$$\frac{1681}{9.5} = 176.9 \text{ } \textit{revolutions}$$

Wheel Diameter and Piston Stroke

A locomotive is running at the rate of 50 miles per hour, the drivers are 6 feet in diameter and the linear velocity of the crank pin is 24.44 feet per second. What is the length of the stroke of the piston?

L. O. S.

The stroke of the piston is equal to the diameter of the circle made by the crank pin. The diameter of the crank-pin circle bears the same relation to the diameter of the drive wheel that the velocity of the crank-pin travel bears to the velocity of the drive-wheel rim. The speed of the drive-wheel rim is 73.33 feet per second

$$73.33 : 24.44 : : 6 : 2$$

Corrugated Flue Collapsing Pressure

Please give me a rule, not a formula, for calculating the collapsing pressure of a corrugated flue.

S. A. L.

Multiply the square of the thickness of the tube in thirty-seconds of an inch by 1200 and divide the product by the greatest outside diameter in inches, multiplied by the length of the flue in inches.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 31,000 *copies are printed.*

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

Contents

PAGE

Priming of Water Tube Boilers..... 428
Throwing a Brick Stack..... 433
The Opportunities of Municipal Ownership 433
Teaching Operating Engineering..... 434
Heat Loss Due to Humidity..... 436
A Case of Overpressure..... 436
Potblyn, Pump Doctor..... 438
Most Economical Amount of CO_2..... 439
Practical Letters:
Loose Piston Caused Knocks.... How to Cut Packing....Shock Absorber....Pipe Fitting....Inexpensive Heater....Cause of Hot Bearings....Boiler Room Repair....Removing a Bottom Cylinder Head.... A Rope Brake for Measuring Power ....Pump Telltale....Scotch Yoke for Steam Engines....Piston Rod Swab .... Efficiency Engineers .... Simple Engine Stops .... Fitting Brasses....Higher Wages .... Diagram Advice Wanted.....440-443
Discussion Letters:
Sizes of Turbine Steam and Exhaust Pipes....Filling Oil Storage Tank ....Mr. Poarch's Diagrams....Value of CO_2 Recorder....Mr. Fryant's Diagram .... Bleeding Receiver to Heat Feed Water....Gage Glass and Water Level....Gage Glasses .... Making Corliss Valve Gear Noiseless....Heat Units Required to Evaporate Moisture in Coal...444-446
Bearing Pressures in Gas Engines..... 447
An Operator's View of the Diesel Engine 450
Power Transmission of Oil Power Vessels 451
Editorials 453-454
Relative Costs of Continuously and Intermittently Operated Refrigerating Plants 455
Increasing Capacity of Compression Plant 458
The Professional Spirit..... 459
The Chief and the Governor..... 460

POWER

Certificates of Quality

Examination questions furnish an ever-ready topic for discussion whenever two or more engineers meet. It frequently happens that a candidate for a license carries from the examination room the memory of one or more questions which he considers particularly unfair, and he seeks sympathy from friends and acquaintances. One feature of the examination is too frequently forgotten. This is the application in which the candidate states his total previous experience in the operation of steam engines and boilers. From this and the personal appearance of the man, the examiner must form a very nearly correct idea of his qualifications for the guarantee which the State is asked to make before a single question is put.

Engineers' licenses are not merely permits to operate boilers and engines. They are certificates that the holders are men who have qualified for the positions they seek. If a candidate lacking the necessary practical experience is given a strictly technical examination, he may be able to answer every question correctly and still be unfit. This is realized by the examiner, who is the one really responsible for the man to whom he grants a license, and he must ask questions that are not to be found in books or published lists. These are sometimes simple, as was once the case with an applicant for a first-class license: "Would it do any hurt if the drop rod on a Corliss engine was an inch too long?" asked the examiner. "Well, I should smile!" was the reply. "If you were running a condensing engine and lost the vacuum gage, how would you regulate the injection water?" was the next question. "I always feel the overflow pipe whenever I go around. I would go around a little oftener than usual until I got a gage." This ended that examination. His application had given his experience and the two simple questions evidenced his mental alertness. These settled, the examiner had no hesitation in certifying that the man was a qualified engineer.

Another applicant was asked how the cutoff on a Corliss engine could be changed. He replied that it could be done by altering the length of the rods running from the governor to the valves. This answer showed at once that he was all adrift, and when the answer was followed by the question: "Would not that throw the governor out of adjustment?" he was speechless. Had he been familiar with the Corliss or any other type of releasing gear, he would have said: "The governor controls the cutoff; it varies with the load and steam pressure, and cannot be changed by the engineer."

If anyone should attempt to lengthen the cutoff on a Corliss engine by changing the length of the rods, the valves might admit steam enough to the cylinder with the governor in its highest position to cause the engine to run away under a light load, and the man who would do this should be debarred from the opportunity for trying it.

The Engineer's Opportunity

One has but to compare the plant of twenty-five or thirty years ago with the modern central station or the power plant of a hotel or office building, in order to appreciate the increased requirements as to the qualifications of the operating engineer. Formerly low-pressure steam was used and as long as the plant ran satisfactorily very little attention was paid to the cost of operating it. Now, however, the engineer must not only be well versed in the principles of steam but he must also be an expert on combustion and, in many cases must have a general knowledge of electricity, refrigeration, heating and ventilating. Moreover, with the present keen competition, he must be able to produce results for the least cost. In fact, the power plant may be considered a factory for the manufacture of electricity or other forms of power and the position of chief engineer corresponds to that of the superintendent in any other manufacturing establishment. His training must be as broad as that of the superintendent and should include a certain amount of business ability as well as technical knowledge; for not only must he be able to direct the operation of the engine room intelligently but he must also be able to meet business men and consulting engineers upon an equal footing. To attain this goal, however, requires study and close application.

Like all other individuals, the operating engineers may be divided into three classes: those who have the "get there" spirit and attain their objects in spite of all obstacles; those who have a desire to advance but do not know how to start about it and lack the initiative to go ahead single handed; and those who lack ambition altogether and are apparently content to leave conditions as

they are, thereby allowing the progressive, energetic men to get all of the good out of opportunities which they logically ought to utilize.

Those belonging to the first class, although ultimately attaining success, often waste much time and energy in haphazard efforts to discover what to study and what not to study. The educational courses of the Institute of Operating Engineers should prove of great benefit to such men by placing at their disposal the experience of others who have gone through the same trials.

To the second class of individuals it should be even more helpful, for not only may it prove a guide to broad practical engineering knowledge, but it should furnish an incentive toward the attainment of such knowledge.

The third class may be dismissed without further comment.

Mr. Pratt's article, in the present issue, in describing the curriculum of the Williamson Trade School shows the good work such schools are doing and indicates the opportunities open to the youth whose inclinations run to the operative side of engineering.

The Oil Engine Fever

The internal-combustion engineers (no misguided levity intended) appear to have gone oil-engine mad. Everywhere one turns, some engine builder is taking up the manufacture of an oil engine, in probably the majority of cases the Diesel type. There are, of course, strong arguments for the oil engine, no matter what the type may be so long as the engine is reliable and economical. The most potent arguments are the absence of all apparatus or machinery besides the engine itself, the fuel economy and the self-firing feature. No boilers, producers, heaters, scrubbers or other pieces of co-operative or auxiliary apparatus; no shoveling or wheeling of fuel and ashes; no ignition apparatus to get out of order at one or more of several dozen points; no pressures to regulate; nothing to adjust or watch outside of the fuel, the lubrication, the cooling water and the moving parts of the engine. It sounds too good to be true, and the actuality is almost as alluring as the picture.

But, notwithstanding these obvious advantages, it is not quite clear why such a wide-spread interest should be suddenly manifested in the building of oil engines. Possibly the rapid development of the Diesel and closely similar engines in Europe has something to do with it; the expiration of the Diesel patents partly explains the increased attention to that type of engine and its rapid progress abroad.

Whatever the impetus behind the movement may be, we do hope that the recent and prospective additions to the list of oil-engine builders will not parallel that deplorable part of American gas-producer history made by the well meaning but hasty people who thought a producer was only a few sheet-iron tanks that anybody could make. The design of a good oil engine requires vastly more preparation and experience than a familiarity with the simple forms of gas engine, a smattering of machine design and a textbook knowledge of the properties of liquid hydrocarbons.

Soft Water and Boiler Scale

Where boiler-feed water is drawn from ponds and streams its character changes very materially with the seasons. In a long dry spell the percentage of dissolved solids is greatly increased, while a spring thaw or a long continued fall of rain has the opposite effect. During a dry period scale will form rapidly because of the high percentage of solid matter in the water. When the supply from the springs is supplemented with the water from melting snow, or surface drainage during rains, its solvent capacity is greatly increased and it attacks the scale already deposited in the boiler. This it loosens from the shell and tubes and the rapid circulation of the water carries it along to regions more or less quiet where it settles to the bottom.

These periods are particularly critical in the case of horizontal tubular boilers which are operated for a portion of the day only and lie with banked fires the remainder. So long as the circulation of the water is rapid, the scale which comes from the shell and tubes will not settle. When the fire is banked the circulation gradually ceases and the flakes of scale go to the bottom. With the slower motion along the bottom of the boiler, a few flakes are caught by the rivet heads of the circumferential seam, others pile up behind these and a bank is soon formed, which the most rapid flow possible along the bottom of the boiler will not dislodge.

Though the mass is somewhat open and water will flow through it fast enough to keep the sheet cool with light firing, the intense heat which usually accompanies the putting of a boiler into regular work evaporates the water faster than it can find its way through it, and the plate, softened by the heat, yields to the pressure and a depression or bag, as it is commonly called, is formed. As the plate stretches the bank is more or less broken, the water finds its way under it, and the circulation distributes it throughout the boiler.

So long as the circulation is rapid, the depression in the sheet will not fill with the traveling solids, but with the first retardation in the flow, the process of scale collection will begin again at the same place.

Bags usually occur in the second course just back of the front circumferential seam and are always caused by the collection of scale loosened from the tubes and shell by the combined influence of the soft water and the sweeping effect of the circulation.

During the snow-melting period, or a long continued wet spell, the surface and bottom blowing should be frequent and thorough, and the boiler should be opened and cleaned more often than at any other time. Not because scale forms, but because that already formed becomes dislodged and can collect where it will do damage.

Taper Fits

From time to time there appear in the papers descriptions of the particular methods adopted in removing a piston or a crosshead from the end of a tapered piston rod. In a drill-press spindle or a lathe center, where provisions for frequent and quick change must be made and the tools for the work are always at hand, the taper fit is both convenient and proper. But on an engine or pump rod, it is a relic of the early days of inexperience in machine making that should be abandoned.

Some engineers object to the use of boiler cleaners which knock the scale off from the outside of the tubes by vibrating a hammer or knocker within, because they occasionally set tubes to leaking. No tube which is in proper condition will be made to leak by the intelligent use of this tool. When scale has been allowed to accumulate about the tube ends and the tube sheet, overheating is liable to occur, and the removal of the scale is quite likely to develop a loose condition and expose a leak. The tubes should be given the reëxpanding which they need anyhow, and the cleaner be given the credit of exposing their loosened condition rather than blamed for producing it.

It is probable that within a short time a new coal-saving scheme will be reported and the same attempts to exploit the purchaser that were so successful three years ago will be repeated. For some twelve years an engineer on the Boston & Albany railroad has been thinking over the problem of increasing the heat value of coal by sprinkling it with some inexpensive solution. Considering the problem solved, about a month ago he began a series of experiments which is said to have shown the possibility of saving, at a modest estimate, one-third of the coal ordinarily burned in locomotive boilers.

In 1910, California's oil production was between sixty-five and seventy million barrels. On the basis of three and one-half barrels of oil for each ton of high-grade coal, the oil production would nearly equal twenty million tons of coal.

Refrigeration Department

Principles and operation of ice making and refrigerating plant and machinery

Relative Costs of Continuously and Intermittently Operated Refrigerating Plants

By Charles H. Herter

It is customary to run the refrigerating machine in plants of 20 tons duty and larger practically continuously throughout the greater part of the year, while in small plants, particularly in those of 10 tons duty and less per day, intermittent operation is the rule, the small butcher or produce merchant finding it more convenient and economical to shut down all machinery at night. It will be necessary to examine the factors influencing these conditions of operation in order to decide whether a given plant should be run 23 to 24 hours daily in summer, or only 8 to 14 hours.

A plant having a maximum capacity of 20 tons of refrigerating effect per 24 hours will first be analyzed, each ton being equivalent to the cooling effect obtained by the melting of 2000 pounds of ice at 32 degrees Fahrenheit. As in melting 1 pound of ice at 32 degrees 144 B.t.u.* are liberated, one ton of refrigeration represents the abstraction of

$$2000 \times 144 = 288{,}000 \text{ } B.t.u.$$

this being the recognized unit for measuring refrigeration. Besides representing the removal of a definite quantity of heat, it also serves to express the rate at which refrigeration is carried on, 12,000 B.t.u. per hour, or 200 B.t.u. per minute, also amounting to one ton of refrigeration.

Let it be assumed that the cold rooms must be kept at about 32 degrees Fahrenheit, which temperature answers for the majority of products stored, and figure on ammonia-compression machines as this is the type most generally used. Also count on expanding and evaporating the ammonia in cooling pipes hung on the walls or overhead coil bunkers of the rooms; air circulation to be caused by the temperature difference maintained between the cold pipes and surrounding air, and not by a fan, because the advantages accompanying the correct use of the latter are not as yet fully recognized in this country.

The refrigeration produced by any ammonia machine is governed by the quantity of vapor formed; the more liquid evaporated the more heat abstracted from the surroundings. Referring to a table giving the properties of ammonia, it may be found, for example, that to evaporate 1 pound of liquid anhydrous ammonia under 15.67 pounds gage pressure requires that 555.5 B.t.u. (latent heat of vaporization) be supplied by the air or materials cooled, the temperature of the resulting vapor being 0 degrees Fahrenheit. The volume of this pound of vapor is 9.028 cubic feet, and is to be pumped away by the compressor. If the liquid ammonia from the condenser reaches the expansion or feed valve at a temperature of 95 degrees Fahrenheit, and the average specific heat per degree in this range is 1.14 (not 1, as formerly believed),

$$95 \times 1.14 = 108.3 \text{ } B.t.u.$$

are applied to first cooling the liquid down to 0 degree; thus there are only

$$555.5 - 108.3 = 447.2 \text{ } B.t.u.$$

per pound available for work, so that for one ton of refrigeration it is necessary to circulate

$$200 \div 447.2 = 0.447 \text{ } pound,$$

or 4.04 cubic feet of vapor per minute. In case a temperature of, say, 12 degrees Fahrenheit is desired in the heat-absorbing pipes, evaporation must take place under 25.43 pounds pressure, the net refrigeration available being

$$548.11 - (95 \times 1.15) = 439 \text{ } B.t.u.$$

per pound; and the amount of vapor required per ton,

$$\frac{200}{439} \times 6.924 = 3.15 \text{ } cubic\ feet$$

per minute. With a compressor of average quality the unavoidable losses will not exceed 25 per cent., so that the piston displacement required per minute per ton may be figured as follows: For 0 degree Fahrenheit,

$$\frac{4.04}{0.75} = 5.4 \text{ } cubic\ feet$$

and for 12 degrees Fahrenheit,

$$\frac{3.15}{0.75} = 4.2 \text{ } cubic\ feet$$

or 22.2 per cent. less than before.

The object of the above demonstration is to prove that the refrigerating capacity of a machine varies with the evaporating temperature, and this again is governed by the suction pressure. Accordingly the commercial capacity rating of a machine is realized only under certain definite conditions, and until a standard has been universally adopted, these conditions should be stated by the builder of the machine. At present 15.67 pounds suction pressure is being favored by some makers because it corresponds with the conditions usually prevailing in cold-storage and ice-making plants. Others adhere to 25 or 27 pounds, which pressures are frequently used in breweries where mechanical refrigeration was first applied on a large scale. As may be seen from the above, the "100-ton" machine of the latter maker need only be 0.778, the size of the other 100-ton machine, while the respective prices asked are often about equal. Approximately, the output of a compressor varies as the absolute suction pressure, a compressor rated and capable of 100 tons refrigerating effect at 25.43 pounds gage being able, at 15.67 pounds gage, to do only

$$100 \times \frac{15.67 + 14.7}{25.43 + 14.7} = 75.6 \text{ } tons\ of\ work$$

In the calculations to follow, use is made of data published by manufacturers who tested horizontal double-acting machines some years ago, their commercial rated capacity being realized at 15.67 pounds gage suction pressure and 185 pounds gage condenser pressure.

To determine closely the probable amount of refrigeration required in a proposed installation is a very difficult matter, as too many unknown factors affect the result. The greatest uncertainty exists in the quantity of goods to be cooled and stored at different times; therefore, the usual way is to estimate all factors as closely as possible, and to make an allowance for contingencies.

Whenever the manufacturer must guarantee to maintain specified temperatures, he is compelled to figure the capacity of his apparatus to suit the most severe conditions occurring in summer, the machine necessarily running 24 hours per day, so as to keep down the first cost; but this time the advisability of installing a machine which can do the work running only about half time is being investigated; thus it becomes necessary to take into account all seasons of the year.

Tables published giving the average air temperature in different cities do not include the temperature obtained in the sun. In New York State this seems to

*Known as the latent heat of fusion of ice.

average 8 to 16 degrees above that in the shade. Again, in the afternoon it is about 9 degrees warmer in the shade than it is in the morning. As only one-half of the supposed building is exposed to the sun, an effective temperature difference of

$$\left(\frac{8+16}{2}\times 0.5\right)+9=15 \text{ degrees}$$

between day and night can be assumed throughout the year and taken as the basis for Table 1.

TABLE 1. AVERAGE TEMPERATURES FOR THE YEAR

Season	Day		Night	
	Temperature, Deg. F.	Difference from 32 Deg.	Temperature, Deg. F.	Difference from 32 Deg.
Summer—June, July, August	85	53	70	38
Autumn—September, October, November	70	38	55	23
Winter—December, January, February	40	8	25	—7
Spring—March, April, May	60	28	45	13

Assume that it is desired to refrigerate the three upper stories of a building, 50x100 feet, each 10 feet high, plus 1 foot for ceiling thickness. The total storage space is 150,000 cubic feet. To itemize the quantity of fresh warm goods to be cooled daily would lead to too much detail. It will simply be assumed that the requirements are, in summer, 12 tons of refrigeration, or 3,456,000 B.t.u. in 24 hours; in autumn, 10 tons of refrigeration, or 2,880,000 B.t.u., and in winter and spring, 5 tons, or 1,440,000 B.t.u. The other work of the refrigerating plant is the maintenance of about 32 degrees temperature in the rooms.

Figure on 43,124 cubic feet of air to be renewed each day, for it is possible to lose this amount through the opening of doors; besides, such air change is needed for hygienic reasons, and for certain products, such as meat, it ought to be greater. The refrigeration involved in this air cooling can be approximated as follows:

One thousand cubic feet of dry air cooled from 85 to 32 degrees requires

$$1000 \times 53 \times 0.019 = 1007 \text{ B.t.u.}$$

One thousand cubic feet of air at 85 degrees and 60 per cent. relative humidity contains 7642 grains of moisture; at 32 degrees and 70 per cent., 1479 grains. The amount to be condensed equals 6163 grains, which divided by 7000 equals 0.88 pound. This multiplied by the latent heat, or 1072 B.t.u. equals 943.3. To cool the condensed vapor takes

Lb. *Deg. F.* *Sp.Ht.*

$$0.88 \times (85-32) \times 1 = 46.6$$

To congeal the condensation on the pipes at 32 degrees takes

Lb. *B.t.u.*

$$0.88 \times 144 = 126.7$$

To cool the ice on pipes to, say, 12 degrees takes

Lb. *Deg. F.* *Sp.Ht.*

$$0.88 \times (32-12) \times 0.5 = 8.8$$

Total per 1000 cubic feet = 2132.4 *B.t.u.*

For 43,124 cubic feet it would require 91,957 B.t.u., or dividing by 53, 1735 B.t.u. per degree temperature difference between that of the rooms and the atmosphere. At smaller differences the work per degree drop will really be less than this, because the moisture content decreases; but this may be neglected, for the above amount of air change is taken arbitrarily.

For completeness an allowance can also be made for the equivalent of two men working in the rooms 10 hours in the day time in summer and autumn. They will emit two pounds of moisture, which item will add to the work, by the above,

$$2 \times \frac{2132.4-1007}{0.88} = 2560 \text{ B.t.u.}$$

They also emit heat, which at 32 degrees Fahrenheit has been found by test to amount to

$$2 \times 600 \times 10 = 12{,}000 \text{ B.t.u.}$$

Sixteen-candlepower incandescent lamps radiate 165 B.t.u. per hour; twice this much, or 330 B.t.u., when old. Six lamps burning 10 hours may, therefore, radiate 19,800 B.t.u. Total for men and lamps, 34,360 B.t.u. For winter and spring only one-half of this will be allowed.

Next the amount of heat entering the building must be calculated. Let the insulation be such that heat cannot leak through the walls and floor at a greater rate than 2.5 B.t.u. per square foot per 24 hours per degree difference; and through the roof at the rate of 2 B.t.u.; that is, 1 B.t.u. per 12 hours.

	Sq.Ft.
Area of floor is 50 × 100 =	5,000
Area of four walls = 300 × 33 =	9,900
Total	14,900
Area of roof	5,000

In summer the heat leaking into the building averages during the daytime,

	B.t.u.
14,900 × 1.25 B.t.u. × (85—32 degrees) =	987,125
Through the roof, 5000 × 1 × (85 — 32 degrees) =	265,000
Total,	1,252,125

At night the leakage is

14,900 × 1.25 B.t.u. × (70—32 degrees) =	707,750
5000 × 1 × (70—32 degrees) =	190,000
Total,	897,750

In autumn the total loss in the daytime amounts to 897,750 B.t.u., and at night to 543,375 B.t.u.

In winter a loss of 189,000 B.t.u. during the day is estimated, and a negative loss or gain of 165,375 B.t.u. during the night, leaving a net heat loss per day of 24 hours of 23,625 B.t.u.

In spring the day figures are 661,500 B.t.u., and the loss at night 307,125 B.t.u.

In reality it is not possible to so distinctly separate the heat losses of day and night, because it is the actual temperature of the two sides of a wall, not of the air in contact with them, that determines the heat transmission. The temperature of the wall follows that of the air only very slowly.

In Table 2 the average for the year is 12.26 tons refrigeration per day, or 61.6 per cent. of the maximum load. In summer one ton of refrigeration takes care of 7540 cubic feet of storage space. In the table the night work is not computed separately, because cooling of goods is not limited to day time only, the work of the machine being kept practically constant during the hours of running.

Excluding the cooling of fresh goods, the work to be done throughout the year fluctuates in this 20-ton plant, the 10-ton plant to follow, and probably in other similarly proportioned and exposed plants, about as follows:

TABLE 2. TOTAL REFRIGERATION REQUIRED IN 20-TON PLANT

Season	Cooling Goods	Heat Loss	Air Renewal	Men and Lights	Total B.t.u.
Summer	3,456,000 B.t.u. = 12 tons	2,149,875 + 7.9 = 19.	91,957 B.t.u. = 9 tons	34,360	5,732,192
Autumn	2,880,000 B.t.u. = 10 tons	1,441,125 + 5.36 = 15	65,930 B.t.u. = 6 tons	34,360	4,421,415
Winter	1,440,000 B.t.u. = 5 tons	23,625 + 0.19 = 5.	13,880 B.t.u. = 19 tons	17,180	1,494,685
Spring	1,440,000 B.t.u. = 5 tons	968,625 + 3.59 = 8.	48,580 B.t.u. = 59 tons	17,180	2,474,385

	Per Cent.
Summer	100
Autumn	67.8
Winter	2.4
Spring	45.5
Average for the year	53.9

Without such an analysis, figuring as usual on the summer duty alone, and knowing that the plant can be arranged to do all the work then in 12 hours, the installation of a 40-ton machine looks justifiable. With the analysis before us, however, it will be seen at once that the 20-ton machine is bound to be more economical even though it must be run 24 hours daily in summer. In autumn it will have to be run only 18½ hours; in spring, 10¼ hours, and in winter 6¼ hours. With a 40-ton machine operating for only half of this time, the cost would be decidedly greater, the piping required would be double, and the whole apparatus, being idle for such a great portion of time, the total cost of operation and maintenance would greatly exceed the cost realized with the 20-ton machine.

While according to the above, a plant doing its 20 or more tons of work in 12 hours in summer is likely to be uneconomical, many plants of 10 tons and less capacity are so arranged that they can do their work in 12 hours, without the cost of operation being increased. This applies especially where motive power other than steam is used and a licensed engineer is not required, one operator being able to handle the whole plant alone.

Take, for instance, a building with three floors 30x74.2 feet, each 9 feet high, plus 1 foot for ceiling thickness, the storage space aggregating 60,000 cubic feet, and the temperature 32 degrees Fahrenheit. Figure on cooling fresh goods daily at the rate of 4.5 tons refrigeration in summer, 3.5 tons in autumn, and 2.5 tons in winter and spring. Using the other figures from the estimate on the 20-ton plant, an arbitrary air change of, say, 34,499 cubic feet per day, will require 73,566 B.t.u.

Dividing by 53, the difference in temperature, gives 1388 per degree temperature difference.

The heat introduced by men and lights would be 34,360 B.t.u., and the insulation used allows 3 B.t.u. to pass per square foot per degree temperature difference per 24 hours.

Area of floor, sq.ft.	2,226
Area of roof, sq.ft.	2,226
Area of four walls, sq.ft.	6,252
Total, sq.ft.	10,704

Then,

$$10{,}704 \times 1.5 = 16{,}056 \text{ } B.t.u.$$

per degree difference per 12 hours. The average amount of heat leaking into the building is given in the following table:

Season	Day, B.t.u.	Night, B.t.u.
Summer	850,968	610,128
Autumn	610,128	369,288
Winter	+128,448	— 112,392
	Net loss per	day, 16,056
Spring	449,568	208,728

In Table 3 the average capacity for the year is 6.2 tons of refrigeration per day, or 62.3 per cent. of the maximum load.

TABLE 3. TOTAL REFRIGERATION REQUIRED IN 10-TON PLANT

Season	Cooling Goods	Heat Loss	Air Renewal	Men and Lamps	Total B.t.u.
Summer	1,296,000 4.5 tons	1,461,096 +5.45=9.95 tons	73,566	34,360	2,865,022
Autumn	1,008,000 3.5 tons	979,416 +3.71=7.21 tons	52,744	34,360	2,074,520
Winter	720,000 2.5 tons	16,056 +0.15=2.65 tons	11,104	17,180	764,340
Spring	720,000 2.5 tons	658,296 +2.48=4.98 tons	38,864	17,180	1,434,340

In summer one ton of refrigeration takes care of 6030 cubic feet of storage space.

If this is to be a gas-engine-driven plant it will be of advantage to be able to shut down and to save the services of an extra man at night. Nor is it necessary to install a 20-ton machine. The work can be done with a 15-ton machine in conjunction with ample piping, so that this small machine during summer can do the work in nearly the same running time as a 20-ton machine working on a lesser number of feet of pipe.

At 20 degrees temperature difference between the ammonia vapor in the pipe and the air circulating in the room, it can be figured that 1 lineal foot of 2-inch pipe will abstract heat at the rate of

$$1.6 \text{ } B.t.u. \times 20 \text{ } Deg.\ F. = 32 \text{ } B.t.u.$$

per hour, or 768 B.t.u. per 24 hours. This means

$$\frac{288{,}000}{768} = 375 \text{ } lineal\ feet$$

of 2-inch expansion pipe per ton of refrigeration. If the gas in the cooling pipes is in a dry state, this heat-transmission coefficient k may be as much as 33 per cent. less, while with wet vapor it may be 33 per cent. greater. The coefficient declines rapidly as the temperature difference decreases, owing to the corresponding reduction in speed of air circulation, and is not likely to improve at differences exceeding 20 degrees unless there is forced air circulation. With 16 degrees difference, k may be taken equal to 1.5 B.t.u.

The 20-ton machine working with ammonia at 0 degree Fahrenheit can do the 9.95 tons of refrigeration in 12 hours if connected up to

$$\frac{2{,}865{,}022}{1.6 \times (32 - 0) \times 12} = 4663 \text{ } feet$$

of 2-inch pipe. If a machine having a capacity of 15 tons refrigeration with ammonia at 0 degree Fahrenheit, is operated with ammonia at 12 degrees Fahrenheit, its output, as already explained, is increased to

$$15 \times \frac{5.4}{4.2} = 19.28 \text{ } tons$$

It can then do the summer work in

$$\frac{9.95 \times 24}{19.28} = 12.4 \text{ } hours$$

but it must be connected with sufficient piping to be able to do its work with 20 degrees temperature difference. It will, therefore, require

$$\frac{2{,}865{,}022}{1.6 \times (32 - 12) \times 12.4} = 7212 \text{ } lineal\ feet$$

The 15-ton machine could undoubtedly be used to the best advantage, but to prove this contention the comparison in Table 4 is made.

As the engines are not being operated at full rated load, an average consumption of 25 cubic feet of illuminating gas may be assumed, which at $1 per thousand equals 2.5 cents per brake horsepower-hour, or the same cost as with gasolene at 18 cents per gallon. These figures are conservative. Lubricating oil for the plant at 30 cents per gallon and using 0.002 gallon per brake horsepower-hour would cost 0.06 cent. All heat abstracted is transferred to the condenser water, 200 B.t.u. for each ton, plus about 50 as the heat equivalent of the power exerted in the compressor, the total being 250 B.t.u. per minute. If the condenser water rises 30 degrees in temperature, there will be required

$$\frac{250}{30} = 8\tfrac{1}{3} \text{ } pounds$$

or 1 gallon per minute per ton. This will also be ample for cooling the engines afterward. An average rate would be 5 cents per 1000 gallons. The attendant's time may be charged for at the rate of 30 cents per hour for the calculated running time. He might do other work when the machine is stopped. The fixed charges in each case include interest on first cost, 6 per cent.; depreciation, 5 per cent.; repairs, 2 per cent.; taxes and insurance, 2 per cent.; total, 15 per cent. The length of each season is 91 days.

In Table 5 the periods of running given are the least needed by the machines to do their work. Each machine operates always at the same suction pressure and upon all of the piping.

TABLE 4. COST OF EQUIPMENT FOR 10-TON REFRIGERATING PLANT USING MACHINES OF DIFFERENT SIZES

Capacity of compressor, gas at 0° F.	10 tons	15 tons	20 tons
Operating temperature, gas at	0° F.	12° F.	0° F.
B.h.p. with 185 lb. condenser pressure, including 25 per cent. increase over the compressor horsepower	21.3	32.4	42.5
B.h.p. gas engine bought	25	35	45
Cost installed, with countershaft and belting, dollars	1100	1500	1850
Compresor piston displacement in cubic feet per minute	54	81	108
Cost of horizontal belt-driven ammonia compressor, with high-pressure side, erected, dollars	2300	2900	3500
Two-inch wrought-iron expansion piping required, lineal feet	2332	7212	4663
Cost of piping, including liquid and suction connections, cents per foot	57	54	55
Total cost of piping, dollars	1329	3890	2565
Prime charge of anhydrous ammonia, lb.	750	2000	1400
Cost at 26 cents per pound, dollars	195	520	364
Total first cost of each plant, dollars	4924	8810	8279

The conclusions to be drawn are, that even with so small a maximum output as 10 tons actual refrigeration per day, marked economy in operating 12 as against 24 hours daily is doubtful when the total yearly cost of operation is considered. In a plant of this capacity 12-hour operation can be made to pay if the power cost per ton of work is kept low. Plants of 15 tons and more output per day will have to be run continuously, while below 10 tons the item of labor per ton decreases with the running time.

Remembering that refrigeration, like the pumping of water, requires less power per ton when performed from high than from low levels of temperature, one is inclined to extend the short running time, especially in winter, and to work the machine with a higher suction pressure; that is, with warmer ammonia. As stated previously, the power per ton of work done would then be lessened. The limit in this direction is set by the temperature difference which must be maintained if the proper relative humidity of the cold air is not to be exceeded. With 20 to 22 degrees difference in temperature between the ammonia in pipes and air in the rooms, the relative humidity can be kept down to about 80 per cent. without a fan; and with 16 degrees difference, to 85 per cent., unless some source of moisture interferes. As will be shown directly, the saving in power realized with this scheme is unfortunately not sufficient in a small plant to offset the increased labor cost attached to a longer operating period.

With the 15-ton machine, for example, the average daily running time in winter could be extended from 3.3 hours to

$$\frac{764\ 340\ (B.t.u.)}{7212\ (ft.) \times 1.5\ (B.t.u.) \times 16\ (deg.\ diff.) \times 1\ (hr.)} = 4.42\ hours$$

the machine operating then at the rate of 14.39 tons refrigeration per 24 hours with 32 — 16 = 16-degree gas. At this temperature the displacement of the compressor required per ton equals

$$3.76\ (cubic\ feet) \times 14.39 = 54.1\ cubic\ feet\ per\ minute;$$

while at normal speed this 15-ton compressor displaces

$$15 \times 5.4 = 81\ cubic\ feet$$

Its speed would, therefore, have to be reduced to 0.668 of normal. The brake horsepower required would be

$$1.49 \times 14.39 = 21.5$$

corresponding to only 61.4 per cent. of 35, the rated brake horsepower of the gas engine. The brake horsepower-hours for the season would be

$$402 \times 21.5 = 8648$$

and if under this reduced load 27 cubic feet of gas per brake horsepower-hour assumed, the gas bill becomes $233.50 as against 9720 brake horsepower-hours at 12 degrees Fahrenheit, which, at 2.5 cents, amount to $243. It therefore means a saving of $9.50 worth of gas, also 64 cents worth of oil, but it would be necessary to pay $30.60 more for labor. Nevertheless, machines are usually run longer, or are run a short time mornings and afternoons, to prevent the temperature in the rooms from fluctuating too much, as this is still cheaper than to accumulate refrigeration in brine-storage tanks, or by other means for the purpose of continuing work after the machine has been stopped.

TABLE 5. COMPARATIVE DATA ON THREE MACHINES AND COST FIGURES

Season	Summer	Autumn	Winter	Spring	Total for Year
Tons refrigeration required per season	$905.45	$656.11	$241.15	$453.18	$2,255.89
10-TON MACHINE					
Hours running, daily	24	17.3	6.36	11.95	
Hours running per season	2,184	1,574	579	1,088	5,425
Per cent. of possible running time (364 days × 24 = 8,736 hours)					62.1
B.h.p.-hours, 5,425 × 21.3 =					115,553
Water, thousand gal. (same for all machines)					3,255
15-TON MACHINE					
Hours running, daily	12.4	9	3.3	6.2	
Hours running per season	1,128	819	300	564	2,811
Per cent. of possible running time					32.2
B.h.p.-hours					91,076
20-TON MACHINE					
Hours running, daily	12	8.65	3.18	5.98	
Hours running per season	1,092	787	290	544	2,713
Per cent. of possible running time					31
B.h.p.-hours					115,301

COSTS PER YEAR

Size of machine used	10 tons	15 tons	20 tons
Gas bill	$2,888.83	$2,276.90	$2,882.53
Lubricating oil	69.33	54.65	69.18
Water bill	162.75	162.75	162.75
Ammonia loss, 10%, 6%, 7% respectively	19.50	31.20	25.48
Wages	1,627.50	843.30	813.60
Total net operating expenses	$4,767.91	$3,368.80	$3,953.54
Fixed charges	738.60	1,321.50	1,241.85
Total yearly cost	$5,506.51	$4,690.30	$5,195.39
Total net operating expenses per ton refrigeration	$2.12	$1.50	$1.75
Total yearly cost per ton refrigeration	$2.44	$2.08	$2.30
Total yearly cost per cubic foot storage space*	9.18c.	7.82c.	8.66c.
Total yearly cost saved over 10-ton machine	.....	$816.21	$311.12
Years required to recover excess first cost over 10-ton machine	.....	4.76	10.8

*These costs are about one-third of the rental charged per cubic foot per year.

LETTER

Increasing Capacity of Compression Plant

Three years ago I took charge of a compression-system ice-making plant having a capacity of 60 tons per 24 hours. There are two machines, one having a capacity of 25 and the other a capacity of 35 tons. For a number of years previous to my taking charge the plant had been a failure, the average daily ice production being 40 tons.

As summer was near when I began work, I had no time to make a thorough investigation and had to do the best I could until the season was over. During the season's run my attention was drawn to the forecooler, where a cooling coil had been installed to cool the distilled water previous to its going to the ice cans. Over the cooling coils a wooden box had been constructed, which completely hid the coils from view.

When the season was over I tore out the box and found two 6-inch headers corresponding in size to the 6-inch suction pipe leading from the brine tanks to the machines. To the headers were connected three 2-inch pipes. The 2-inch pipes told me the story of the failure at a glance. I removed the coils and drilled and tapped the headers for seven more 2-inch pipes. This made 10 pipes altogether. As it takes nine 2-inch pipes to equal the area of one 6-inch, it may be readily seen how much the returning gas was restricted in its flow from the tanks to the machines.

When we started up the next season in full, we turned out from 66 to 70 tons of ice every 24 hours, and we have kept up this record each season ever since.

J. A. BLACKSTONE.

Youngstown, O.

An approximate rule for the length of belting is as follows: Add the diameter of the pulleys together, divide the sum by 2, multiply the quotient by 3¼ and add the product to twice the distance between the centers of the shafts. An even better rule than this is to cut out the figuring and use a tape line round the pulleys.

The Professional Spirit*

By W. D. Ennis

The operating engineer is a business manager. He has wonderful opportunities. Whether he profits by them depends completely on himself. The Institute of Operating Engineers should cultivate the faculty of self-education.

*Abstract of address delivered at annual meeting of the Institute of Operating Engineers, New York, Sept. 1, 1911.

It would be a very obvious question if someone were to ask, what is an operating engineer? The most obvious and direct reply to the question is, an operating engineer is a man who operates an engine. But if this organization (the Institute of Operating Engineers) means anything, if it thus far stands for anything at all, it stands opposed to any such definition. The operating engineer who is a master of his craft must be very much more than an engine operator. The Institute of Operating Engineers is not intended to be a society of machinery attendants; it is a professional body of national—yes, international—scope, including all men who have to do with the responsible care of machinery in motion. Our national institutes of mining and electrical engineers have their perfectly definite fields: the civil engineers deal with structures; the mechanical engineers design machinery; we operating engineers make it go and keep it going.

We should take an unnecessarily modest view of our function if we concluded, therefore, that the operating engineer is a caretaker, a hand worker, while all the other engineers are brain workers. We are a necessary part in that mechanism of production of which they also are parts. The great raw material with which we work is fuel, brought to us by the mining engineer. The electrical and mechanical engineers provide us with tools to work with, in edifices and structures which we owe to the genius of the civil engineer or the architect. From fuel we produce power and light and heat and those other services which have become essential to civilized humanity. Their production with efficiency and effectiveness depends in a peculiar way upon us. The operating engineer is the most important single factor in the performance of the power plant.

Our Institute, then, recognizing the commercial importance of the work of its members—the momentous issues which depend upon them—seeks to obtain for them commensurate recognition. It would substitute logarithms for overalls, the slide rule for a monkey wrench, perhaps a rolltop desk for a tin dinner pail. But these are only parts of its aim. As long as the operating engineer is denied the recognition his work merits, just so long will the field of operating engineering fail in a general degree to attract the best type of men.

Our young men become foremen, designers, construction men—but they rarely go in for power-plant operation. Why? Because, while the responsibility and the opportunity for efficiency there are as great as anywhere else, the conditions of work are oppressive and the reward for efficiency inadequate. Under present circumstances the man who enters operating engineering must make some distinct sacrifices. Two results follow: The profession secures a few, and only a few, devoted men of the highest type; men who must, because of their very make-up, be engineers, men who are impelled to that work just as St. Paul was impelled to preach the gospel, who would be engineers for fun, even if they had to be something else for a living. It also secures a large proportion of men not of the second but of the third and fourth ranks, men who go in for plant operation because of lack of ambition to enter more promising fields.

The bad conditions in operating engineering thus react, bringing into the vocation men not qualified to measure up to their opportunities; men too small in intellectual stature to handle the problems involved in making power from coal. This is the more serious problem that our organization aims ultimately to rectify. The operating engineer is to be a professional man in precisely the same sense as the civil engineer may be.

The steam engine, as a working machine on a broad commercial scale, is little more than a century old. A hundred years ago, when it first became generally known, it was the fashion in certain quarters to decry machinery and its effects. Such honest men and great thinkers as Thomas Carlyle and John Ruskin, for example, feared that the beauty of life would disappear and the dignity and art of handicraft be eliminated by the advent of such things as the power loom, the spinning jenny and the engine. They denounced the coming age as one of mechanism rather than of men, one in which landscapes would be blotted out by coal smoke and waterfalls drained that mills might run.

Yet on the whole, while chimney and furnace smoke may disfigure the land and in places mar its beauty, nevertheless steam power has, perhaps more than any other material invention, raised rather than lowered human nature and humanity's capacity and opportunity for enjoyment.

Power does not enslave men; it sets men free. It substitutes brainwork for handwork, skill for brute strength. The workman of today has but to guide the tool. The invisible engine far off provides the effort. All of the unconsidered conveniences of civilization we owe in a large measure to artificial power.

In its practical everyday aspects, let us regard the scope of activity of the engineer. We have already considered his interest in the provision of light, heat and ventilation. He has charge also of the elevators and other machinery of a modern building; in hotels and hospitals he supplies steam and refrigeration for a score of purposes; he supervises the generation of electric, hydraulic, pneumatic and other forms of power; he is responsible for the intricate equipment involved in modern fire-prevention systems. In manufacturing plants, he may have the care not only of the apparatus connected with the utilization of steam in process work, but also of the machinery and physical plant as a whole. Several of this Institute's members are at the head of important works; for it is by no means an illogical step for the man who progresses from the generation of power to its utilization—and thence to the care of apparatus and structures and the supervision of nonproductive material stores, with responsibility perhaps for the largest items in production cost—to control ultimately the general and immaterial mechanism of that production.

In New York City and other large municipalities every operating engineer in responsible charge of a private power plant is a competitor of the public lighting and power corporation. He is no greasy mechanic; he is a man engaged in a strenuous business, bound to show in his final costs the reason for his existence and against him are massed the best engineering and commercial talents of a highly developed organization. The man who can live against such odds is no small man.

The object of the Institute of Operating Engineers, in one word, is *service*—higher service. That object includes, or will include, all others. The man who serves most deserves most; in the long run, attains most. We wish to be professional men rather than machinery operators. Both the justice and the realization of our ambition will be for a time denied us. If we seek to attain it by demagogic agitation or undue self-assertion, they may be effectively denied us for a long time to come. But if our platform be this, we know that the wastes of the power

plant are largely due to bad operation; we purpose to better that operation by inducing better trained and better educated men to enter power-plant service, then that ideal of higher service must appeal to all and offend none.

The improvement in education and training which this Institute proposes as a remedy for present bad conditions will be brought about in various ways. First of all, we must make the fullest possible use of all existing agencies. The technical press, or at least that part of it which deals particularly with power-plant matters, is one of the foremost of the educational influences with which we must as a matter of course coöperate. Schools and colleges, in their regular or extension courses, and correspondence schools as well—all of these have their special fields of efficient work. They and we will be mutually helpful as we bring their activities close to our membership. Here in the city of New York opportunities for higher study have already been provided. At Columbia University classes have been conducted for some years in certain instances, under the instruction of men who are members of this Institute, in various subjects pertinent to operating engineering. In the borough of Brooklyn another educational institution will, it is expected, offer this winter courses of study contemplated in the requirements laid down for the grade of master operating engineer.

But, in order to develop the genuine type of professional spirit among our members, present and future, we need something more than trade schooling or even technical education. Two or three initial letters after a man's name do not make him an engineer. No school or university can make an engineer. It takes time and some dirt and perspiration and a good boss—and a variety of other things to do that. There can be no true professional spirit among us until we develop the faculty for self-education. We are apt mistakenly to think that our brother engineers in the civil and mechanical branches get their "theory" in school and their practice afterward. On the contrary, the most important engineers I know are devoting a great deal more of effort to theoretical study—namely, to a mastery of first principles—now, than they ever did as students. So also must we. An engineering society becomes of great national importance only as it becomes a clearing house for original scientific thought.

To summarize, what are the essentials of the so called professional spirit? Perhaps we may say, activities which involve brain work rather than hand work; a clearly defined special field, in our case the responsible care of machinery in motion; commercial and industrial and social importance of the vocation; and finally a strict responsibility for ultimate costs and ultimate results.

The operating engineer is a business manager. We do not ordinarily regard a business manager as a professional man. Indeed, there has always been a strong distinction drawn between commercial (or industrial) and professional occupations. For the past three years we have been reading a great deal about managers and management—scientific management and other kinds of management. The papers have been full of it and our heads have been bewildered by it. What does it all mean? Simply this, that management is becoming a profession, like law or medicine or (most notably of all) engineering. Men are no longer to be managers by divine right; they are to learn to rule, and to rule constitutionally, just as all kings on the other side of the water have had to learn in the last century or two.

This movement was due, as I view it, to the mechanical engineer, the trained, educated mechanical engineer. Going into the shops and mills, he revolutionized methods and processes by applying his superior knowledge of fundamental principles, and now he is revolutionizing management. The manager of today is more and more frequently a trained engineer (once he was a graduated office boy), and management is now recognized as based on certain fundamental principles, just as engineering is. We do not know them all yet, but we are steadily discovering them.

The best training for producing a manager has not yet been ascertained. One good kind of preparation is the study of engineering. As has been said, engineering is superlatively a professional vocation. To be an engineer alone goes far toward fitting a man for a position of executive authority, and this is most particularly true in operating engineering. In the factory as a whole the mechanical engineer has many rivals for the chief position. The head bookkeeper, or even the head stenographer, may "win out" over him. But in the power department, what rival has the operating engineer? If he fails to manage his work in a businesslike and efficient way, there is not a soul on earth to do it for him.

And just there lies our strength and our weakness. The opportunity is wholly ours; it is the greatest opportunity ever turned over to a single set of men; but because no one competes with us for it we often, in the great majority of cases, I fear, fail to grasp it adequately. I repeat, then, the operating engineer's work is that of a business manager. He is given a plant, required to maintain it in good condition and held responsible for the cost of power. In theory if not always in fact, he has a clean-cut business proposition, and if the final result is what it should be, then, humanly speaking, there is nothing on earth too good for him.

The Chief and the Governor

By H. M. Phillips

Strange performances that add to the joy of living take place in the world of mechanics frequently and at all places, but the record of the old A. and B. plant will probably never be surpassed.

The plant had been idle for a year or more and there was the usual trouble in getting an extensive though by no means modern steam plant into operating condition; in the midst of which the chief engineer departed, never to return. There were several men on the job who applied for the vacant position; it is hard to say why the "hero" of this story was chosen, unless it was because he had never had anything to do with the steam plant before so that there was nothing in that particular line against him.

At the time of his appointment there was but one engine running, a small Porter, with a "Gardner" governor, that drove a generator supplying light and power for a few motors. Several days passed without disaster and the chief grew in importance; then the governor belt broke. The safety stop did its work, the chief was soon on the spot and he lost no time in getting on a new belt; but the engine would not run (the safety catch had not been reset). After a somewhat lengthy investigation the trouble was traced to the governor and the chief took it apart, and by the time he was through with it there was real trouble and it had to be sent to the machine shop for repairs that would take the better part of 24 hours. Lights and motors were indispensable, however, and the engine was therefore run without a governor. An assistant engineer was stationed at the throttle and a dynamo tender at the rheostat, and, although the service was not of the best they both earned their pay that day.

The chief was not exempt from the rule requiring a time card to be filled out each day. The card was of unusual size, with ample space allowed for the different jobs upon which a man worked. If you had never before realized the importance of the position of chief engineer you could hardly fail to do so—at least, you could be certain that the chief himself did so—by a glance at his time card. Written diagonally across its face, in a remarkably bold and aggressive hand that filled the entire space, was:

Acting Chief Engineer

On the day following the trouble the chief's card came to the office as usual; and another card lay close to it in the pile; it was that of the hard-worked man at the throttle. The general style of the latter's card closely followed that of the chief's; there was the same bold and aggressive handwriting, if anything, a trifle larger and heavier, but the wording was slightly different. It read:

Acting Governor

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Jahns Engine and Turbine Governor

In the accompanying illustrations the Jahns steam-engine and turbine governor is shown in detail. A skeleton of the

FIG. 1. GOVERNOR BASE

governor is shown in Fig. 1; the two main weights are shown in position in Fig. 2, and a sectional view of the governor is shown in Fig. 3.

The two weights are guided in a radial straight line perpendicular to the spindle by three rolls on the lower surface sustaining the weights and two rolls on the

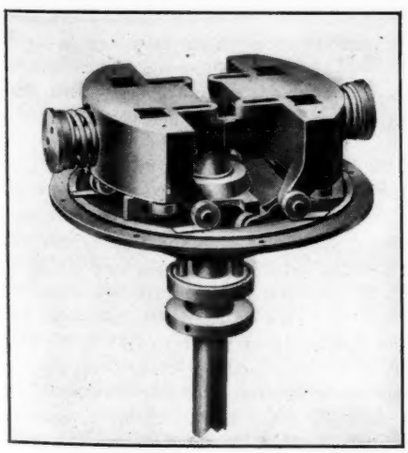


FIG. 2. GOVERNOR WEIGHTS

sides resisting the force of inertia which would tend to keep the weights revolving at the same rate while the engine—and, therefore, the governor casing—increases or decreases its speed by an infinitesimal amount. The centrifugal force of each weight acts directly upon its spring so that all lever joints are entirely free from any centrifugal or spring force.

The transmission of the motion of the weights to the sliding sleeve on the spindle is effected by the bell cranks fulcrumed on the lower casing, the upper arms engaging, by means of rolls, the vertical straight slots in the weights; the lower arms engage in sloping slots in the spindle sleeve. The angle of this slope is fixed in such a manner that the centrifugal force of the weights, as transmitted to the sleeve, is practically a constant force, being the same for each position of the sleeve throughout its stroke.

The casing is entirely inclosed, as shown in Fig. 4, and all of the lower pins and slides are in a bath of oil. The oiling of the upper pins and slides is effected through the oil cup on the top of the governor and can be done while the governor is in motion. When the oil has attained a certain hight any additional amount will cause an overflow. This surplus is conducted to the rubbing surfaces of the sliding spool located below and outside of the casing. In this manner every point of possible friction is automatically oiled.

The governor possesses small internal friction, the lever joints being free from all centrifugal and spring forces, and from any side strain caused by force of inertia of the weights. There is also the least possibility of change in the working parts through wear.

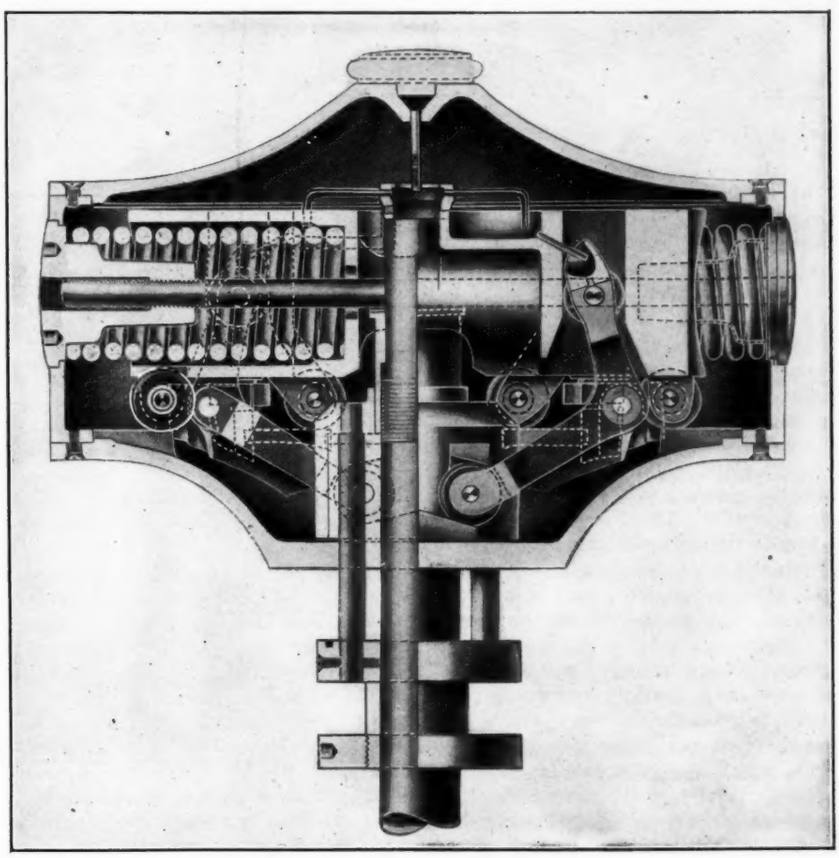


FIG. 3. SECTION THROUGH GOVERNOR

In case an adjustment of the governor not exceeding 10 per cent. is desired, a speed regulator may be used.

A change in the revolution of the governor is accomplished by means of a spring so arranged that it can be loaded or unloaded, and giving a constant downward pull on the sliding sleeve at all times.

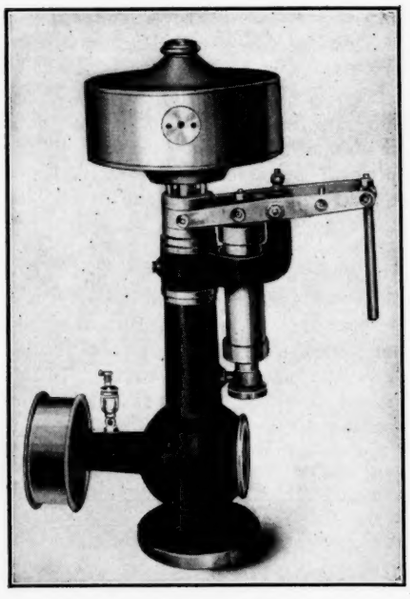


FIG. 4. GOVERNOR COMPLETE

In Fig. 5 is shown a variable-speed governor, which by means of an auxiliary spring located inside of the regular stand, it is claimed, is capable of taking care of a variation of 100 per cent.

The auxiliary spring surrounds the governor spindle and rotates with it, the lower end of the spring resting on a collar which is free on the spindle but is supported by a cross key passing through a rod inside the governor spindle, which is hollow. This rod transmits the pressure of the auxiliary spring, by means of a key, to the roll sleeve which is located inside the governor.

The upper end of the auxiliary spring has a collar resting upon it which is also loose on the spindle and turns with it. The upper side of this collar forms half of a ball bearing, the other half of which is part of a collar surrounding the spindle, and has ears which pass out through slots in the side of the governor stand, the ears keeping this collar from revolving; the outer ends of the collar ears are attached to a handwheel which fits the threaded portion of the outside of the pedestal; therefore, adjusting this handwheel will compress or release the spring to any desired amount.

This type of governor is particularly adaptable to compressors and pumps.

These governors are manufactured by the Massey Machine Company, Watertown, N. Y.

Consolidated Safety Valve

In designing this valve the spring has been so proportioned that it will have the best values for both fiber stress and compression under the highest steam pressures.

The spindle of this valve has a central thrust upon the valve disk and the spring is prevented from binding on the spindle by mounting the spring to the end of the compression screw above and to the spindle below. This consists of two ball-and-socket bearings of the same size which allow the spring ends to freely assume their normal position.

The upper trunk of the valve disk overlaps the outside of the spring case. This practically leaves no area upon the top of the disk exposed to the exhaust-steam pressure and makes the valve disk entirely independent of pressure conditions within the valve case.

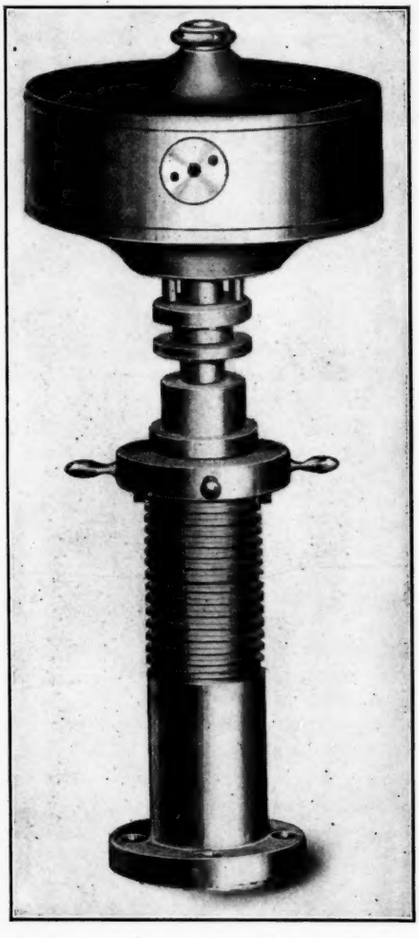
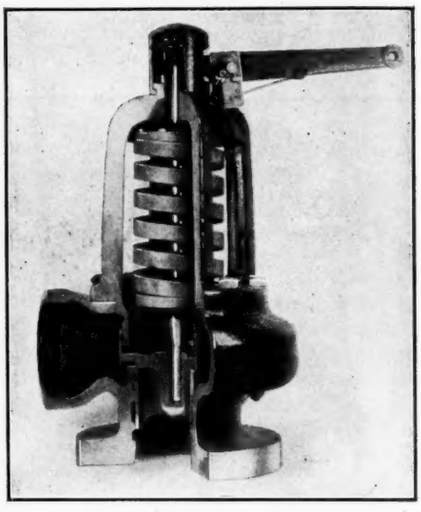


FIG. 5. VARIABLE-SPEED GOVERNOR

Another feature is the hand-ground balled seats which maintain a bearing at the seat despite any axial change of the disk position.

The long, broad-faced wings of the feather below the seat and the ample bearing of its trunk on the spring case above, together with the low bearing of the spindle upon the feather, make the lifting of the valve smooth and positive in action.

The blow-back adjustment of this valve is obtained by means of the original Richardson adjusting ring. It not only gives a definite and positive control of the blow-back adjustment for close or wide regulation, but forms a factor in obtaining the large relieving capacities of these valves. A relief nut on the top of the stationary valve spindle makes it possible to take the valve apart for re-



CONSOLIDATED SAFETY VALVE, "TYPE B"

grinding or inspection without disturbing the adjustment of the valve.

In this type of valve the casing is made of steel, but the brushing and other mountings are of nickel. The valve is designed for service where superheated steam is used. The spring is exposed to the atmosphere and steam does not come in contact with it. By referring to the illustration it will be seen that the valve body is cast with a steam passage around the outside of the valve seat. The upper section of the valve is made with a projection upon which the valve disk is guided as it opens and closes. This also prevents the steam from escaping around the spring.

When the valve blows the valve disk is lifted, thus compressing the spring. Steam escapes through the opening between the valve disk and seat into the chamber surrounding them and escapes to the atmosphere through the opening at the left. This valve is manufactured by the Consolidated Safety Valve Company, 85 to 87 Liberty street, New York City.

In Paris recently a monument was unveiled on the Place Saint Ferdinand des Ternes to Léon Serpollet, whose initial journey from Paris to Lyons in his steam car in 1890 caused a sensation. When he first drove about the streets of Paris, numerous complaints were made to the prefect of police that the lives of citizens were being endangered while crossing the streets.

Minnesota State Convention, N. A. S. E.

The second and by far the most successful convention of the Minnesota State Association of the National Association of Stationary Engineers was held at St. Paul, Minn., August 23 to 26. President H. M. Germain presided throughout the four days' sessions. The convention was called to order by Past President J. M. Williams, of Minneapolis, and addresses of welcome were delivered by Mayor Herbert P. Keller, of St. Paul, a member of the organization, and by Mayor James C. Haynes, of Minneapolis.

During the different sessions a number of interesting and instructive lectures were delivered. Henry Sims, of Erie, Penn., president of the Sims Company, spoke Wednesday on "Feed-water Heaters," and ex-National President Wilson gave a very able discussion on boilers at Saturday's meeting.

Among the others who spoke were H. D. Barnard, of Minneapolis, on "Incandescent Lights"; National Secretary Fred Raven, on "The License Law"; Gen. Henry Harris, of Chicago, on "The Opportunities of a Stationary Engineer"; W. A. Converse, of Chicago, on "Boiler Troubles Attributable to Feed-water Heaters"; E. P. Carish, of Minneapolis, assisted by E. Powers, of St. Paul, on "Ventilation."

The committee reported 32 delegates present at the convention, and the general attendance was in the vicinity of 300. The association, following the recommendations of the legislative committee, decided to set aside a sum of money not to exceed $500 a year for legislative purposes, providing this was possible. It was decided also to appropriate $200 yearly for assisting the officers in forming new organizations.

The convention unanimously indorsed Fred W. Raven for reëlection as national secretary and adopted resolutions indorsing Jesse M. Williams, of Minneapolis, for vice-president of the national association.

The president's message was read on Thursday evening. In it he spoke of the progress which the association had made during the last year and said the poor showing that had been made in organizing new associations was due to lack of funds and not to any lack of energy by the officers.

During the past year the State law has been kept prominently before the people. Several open discussions on this subject were held during the convention and the members were roundly scored at different times for their lack of energy in this matter. It was shown that the committee having the work in hand had labored continuously to secure the passage of the bill by the Minnesota legislature, but that their efforts had failed just when everything seemed accomplished. In his discussion on this subject, Mr. Raven said that the association could hardly expect to do everything in one year; and that it must educate the engineers themselves and the public as to just what good will be accomplished by the bill. Mr. Raven also asked that the delegates to the national convention be instructed to support the appropriation of a budget for the purpose of helping new associations.

Over 45 manufacturers and retail dealers exhibited their products at the convention. This was made a special feature of the work and the results were highly satisfactory.

During the week a number of social affairs were arranged. The election of officers was held Saturday and resulted as follows: F. J. Streiff, president; J. P. Crane, vice-president; James McGeary, secretary; Albert Johnson, treasurer; T. S. F. Hayes, State deputy; P. B. Wells, conductor; W. McIver, doorkeeper; J. Orbeck, trustee for three years; J. D. Roberts, trustee for two years.

OBITUARY

George K. Lloyd, for 25 years engineer at the Queen Dyeing Company's plant at Providence, R. I., died at his home in that city on September 1. He was one of the best known engineers in the New England textile field. Mr. Lloyd was born in Baltimore, but came to Providence when a young man. He is survived by two daughters and a son, who is an engineer at the Queen plant. The funeral was held on Monday, September 4, from his late residence.

PERSONAL

C. E. Miller will be in charge of the branch office opened on September 11 by the Standard Welding Company, of Cleveland, O., in the Ford building, Detroit, Mich.

W. W. Reece, formerly of the Corn Products Refining Company, has recently taken charge of the power-plant economy department of the W. H. Zimmerman Company, engineers and constructors, offices in the First National Bank building, Chicago, Ill.

Thomas H. Platt, who is well known to the engineers of New York, is now associated with the Dearborn Drug and Chemical Works, and will make his headquarters at the Eastern office of the company, 299 Broadway, New York. Mr. Platt's territory will comprise Greater New York.

Benjamin T. Delafield, who formerly represented Lunkenheimer Company for a number of years in the St. Louis and Kansas City territory, has become connected with the Best Manufacturing Company, of Pittsburg, Penn., to handle its line of valves, fittings, flanges, pipe bends, fabricated pipe and other power-plant material in the same territory. He will make his headquarters in Kansas City.

Louis Bendit has been appointed by the Hope Engineering and Supply Company, of Pittsburg, as manager of its Western office at the New York Life building, Kansas City, Mo. Mr. Bendit will have associated with him a corps of experienced engineers and will be prepared to give careful attention to all inquiries in consulting and contracting engineering along the line of natural gas. He will also have charge of its sales agencies of Miller gas and oil engines, C. & G. Cooper gas engines, Hammon gas-pipe couplers and Sprague gas meters.

CHICAGO'S SMOKE INSPECTOR

SOCIETY NOTES

At a recent meeting of the executive committee of the American Society of Mechanical Engineers, the following committee on standard rules for care and construction of boilers was appointed, subject to the approval of the council: John A. Stevens, Lowell, Mass., chairman; Edward F. Miller, Boston, Mass.; Charles L. Huston, Coatesville, Penn.; Herman C. Meinholtz, St. Louis, Mo.; R. C. Carpenter, Ithaca, N. Y.; William H. Boehm, New York, and Richard Hammond, Buffalo, N. Y. From the experience of the society in regard to its codes for testing boilers, engines, etc., there is reason to believe that a set of carefully prepared specifications, formulated and recommended by such a committee will be recognized as a standard by legislatures and officials, and that uniformity in legal provisions will thus be obtained.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

Graham Hood, who writes the little stories of practical, every-day philosophy for the New York *Evening Globe*, recently published one on the importance of a man's equipping himself with the right knowledge and training, in the right way, and at the right time in his career.

To quote a part of it:

"If there is anything that it is absolutely necessary that you should know, especially in your business life, there is every probability that you will in some way manage to acquire this information some time. If you are wise you will go about the work of acquiring this knowledge systematically, beginning at the earliest possible moment. Because you fail to do this, however, don't imagine for a moment that you are to go through life in the state of ignorance that you have adopted. Even though you might be so foolish as to deliberately elect to know nothing that might help you get on in the world, you can't keep yourself from gaining this knowledge, for the only way to escape the lessons that Schoolmaster Experience teaches is to stop living. As long as breath remains in our bodies we are compelled to continue our studies in this school.

"The mistake that a great many persons make, however, is that of waiting until the knowledge comes to them instead of going after it. It may be true that the knowledge may come eventually, but what are to become of the countless opportunities when the sometime-to-be-acquired knowledge would enable you to change a failure into a successful achievement?

"It is true that it costs something to secure this knowledge at first hand. It costs a great deal of time, much patience and persistence, and possibly a little money, but if you could compare the cost of the knowledge you get in this way, and that for which you have to wait until experience can get a chance to teach you, you would be amazed to see how much cheaper it is to secure your training in the right way.

"In the first place, the man who knows just what he wants to do, and exactly how he should go to work to get these results, reduces the possibility of mistakes and failure to a minimum. Mishaps may occur, for it is not easy to devise a positive safeguard against such incidents, but should they happen the man who knows how can usually find an easy way to remedy them. It is the fellow who does not know, and who is waiting for experience to teach him, who falls into all sorts of costly pitfalls. Experience does teach him in time, but in the meanwhile he must meet the cost of his experiments, and the expense of tuition in the School of Experience is far in excess of that which is charged for the thorough training that he may so easily secure at the beginning of his career."

The moral is, don't wait until knowledge comes to you—*go after it.*

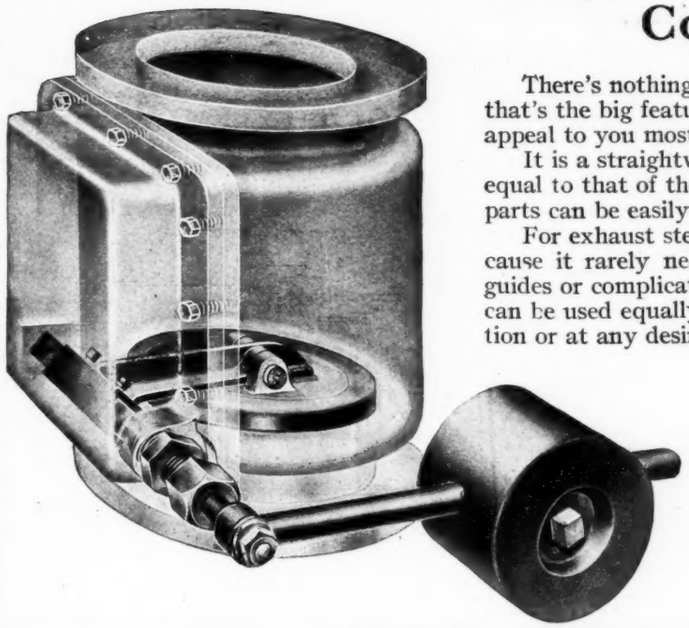
It is POWER'S business to bring you a fund of valuable knowledge every week—all you need to do is to go after it, to read it.

The advertising section of this paper represents in reality an enormous, costly system of engineering education, which comes to you every week.

If you don't conscientiously read and study the ads you are neglecting a great opportunity.

The information is there—*go after it.*

Excelsior Straightway Back Pressure Valve Simple And Practical In Construction



There's nothing to get out of order or cause rouble—that's the big feature of the valve—the feature that will appeal to you most.

It is a straightway valve; the area through the seat is equal to that of the pipe. When not needed the working parts can be easily and quickly thrown into the cover.

For exhaust steam heating it is especially valuable because it rarely needs repairs as there are no dashpots, guides or complicated levers. As a back pressure valve it can be used equally well in a ver ical or horizontal position or at any desired angle. It is also adapted for use as a relief or free exhaust valve, for condensing engines, and can, when desired, be supplied with body arranged for water seal, in which case it can be used only in a vertical pos:tion.

Fitted with the Jenkins Disc which gives long wear and which, when necessary, can be easily replaced.

The Jenkins Diamond Steam Trap

This small and simple steam trap is ideal for use when there is a moderate amount of condensation such as steam-heating coils, steam jackets and kettles, heaters and similar places.

Automatic in action; absolutely reliable; it removes the condensation without wasting any steam.

It will remain open as long as water escapes and closes as soon as steam strikes the plug.

Sellers Restarting Injector

A well-made injector, strong and durable. It has a wide range of capacities. It lifts the water promptly with hot or cold pipes—restarts instantly after a temporary interruption of the steam or water supply.

Made of the best bronze, all parts screwed and the tubes do not depend on the pressure of steam to hold them in place, so there is no danger of leakage.

Your dealer can supply you. If he fails to do so—we will send you name of nearest dealer who will.

Send for our Catalog.

Jenkins Bros.

80 White St., New York **35 High St., Boston** **133 N. 7th St., Philadelphia**
300 West Lake St., Chicago

OUTLINE OF TOPICS

		PAGE
PRIMING OF WATER TUBE BOILERS The fundamentals of a proper circulating system and the circulation in several well known types of water-tube boiler.	*T. F. Maguire*	428
THROWING A BRICK STACK The stack was located in confined quarters and had to be thrown accurately in a certain direction.	*A. D. Williams*	433
THE OPPORTUNITIES OF MUNICIPAL OWNERSHIP The record of the Pasadena, Cal., plant shows that a city can obtain results far beyond the average expectation.		433
TEACHING OPERATING ENGINEERING Methods employed at the Williamson Trade School for training operating-engineering apprentices.	*J. A. Pratt*	434
HEAT LOSS DUE TO HUMIDITY From a recent test it was shown that a loss of 10 or 12 per cent. of the heat units in coal may be caused by the humidity of the air.	*John G. Moxey*	436
A CASE OF OVERPRESSURE A gage registering 300 pounds due to a frozen pipe connection was the cause of great excitement in the power plant.	*J. E. Terman*	436
POTBLYN, PUMP DOCTOR Changing the temperature of the supply to a hot-water pump created vapor in the suction and the usual troubles resulted.	*John Watson*	438
MOST ECONOMICAL AMOUNT OF CO_2 The significance of CO_2 in its relation to excessive or irregular fuel supply is almost as important as its relation to excessive air supply.	*A. Bement*	439
BEARING PRESSURES IN GAS ENGINES Average maximum bearing pressures computed from empirical data used by American manufacturers in the design of horizontal and vertical stationary gas engines.	*G. W. Lewis and A. G. Kessler*	447
AN OPERATOR'S VIEW OF THE DIESEL ENGINE The absence of the usual ignition system is appreciated, but the splash system of lubrication is disliked.	*William F. Caton*	450
POWER TRANSMISSION ON OIL POWER VESSELS The author favors a crude-oil engine coupled directly to the propeller with a substitute for compressed air used in starting, taking less space and more easily prepared.	*John F. Wentworth*	451
RELATIVE COSTS OF CONTINUOUSLY AND INTERMITTENTLY OPERATED REFRIGERATING PLANTS Method of computing total refrigeration required in a plant, operating expenses and the proper size of compressor to use.	*Charles H. Herter*	455
INCREASING CAPACITY OF COMPRESSION PLANT Changing pipe connections nearly doubles capacity for making ice.	*J. A. Blackstone*	458
THE PROFESSIONAL SPIRIT Self education the keynote. The engineer of today must be a business manager.	*W. D. Ennis*	459
THE CHIEF AND THE GOVERNOR The governor was an assistant engineer who regulated a lighting unit by means of the throttle.	*H. M. Phillips*	460

PRACTICAL LETTERS 440-443

LOOSE PISTON CAUSED KNOCKS:
Tightening nut 0.013 inch stopped them.

PIPE FITTING:
A few suggestions.

SHOCK ABSORBER:
Piston backed by spring used as air chamber.

HOW TO CUT PACKING:
Cut it square.

INEXPENSIVE HEATER:
Made from galvanized tank.

CAUSES OF HOT BEARINGS:
And how to cure them.

REMOVING A BOTTOM CYLINDER HEAD:
By the use of long studs.

A ROPE BRAKE FOR MEASURING POWER:
A simple apparatus used on small engines.

PISTON ROD SWAB:
Saves three-quarters of the oil.

SIMPLE ENGINE STOPS:
May be used on pipes up to 3 inches diameter.

FITTING BRASSES:
Sapolio of great assistance.

BOILER ROOM REPAIR:
Copper washer stops leak around tie rod.

PUMP TELLTALE:
Incandescent lamp lights at every stroke.

SCOTCH YOKE FOR STEAM ENGINES:
Why is it not more used?

EFFICIENCY ENGINEERS:
Men with divine inspiration and no experience.

HIGHER WAGES:
Education rather than legislation is needed.

DIAGRAM ADVICE WANTED:
Crank-end diagram defective.

DISCUSSION LETTERS 444-446

SIZES OF TURBINE STEAM AND EXHAUST PIPE:
A difference of opinion.

MR. POARCH'S DIAGRAMS:
Pointing out the defects.

FILLING OIL STORAGE TANK:
By means of air pressure.

VALUE OF CO_2 RECORDER:
Depends largely on the user.

MR. FRYANT'S DIAGRAM:
The trouble is leakage past the piston.

GAGE GLASS AND WATER LEVEL:
Water colder and slightly lower in glass.

MAKING CORLISS VALVE GEAR NOISELESS:
By substituting black fiber for case-hardened tail piece.

BLEEDING RECEIVER TO HEAT FEED WATER:
The saving is from 3 to 6 per cent.

GAGE GLASSES:
Information wanted.

HEAT UNITS REQUIRED TO EVAPORATE MOISTURE IN COAL:
There are two kinds: crystalline and surface.

INQUIRIES OF GENERAL INTEREST 452
EDITORIALS 453-454
NEW POWER HOUSE EQUIPMENT . . . 461-462
MOMENTS WITH THE AD. EDITOR 464
BUSINESS ITEMS 47
ADVERTISING INDEX 49

SIFTED OUT!

Could YOU Stand the Test?

If you have ever applied for a first-class position this is what occurred: There were several in the line-up. As you went up, one by one, you were all put into a mental sieve. The boss gave all a sifting, but they fell through onto the junk pile—till *only one man* remained.

The boss picked out this *one man* and told him he could go to work at once. He had the education—the training that enabled him to stand the sifting test. He had developed not merely his body but his head. To all the other applicants the boss said: "Good morning, we won't need you."

When you train *your* brain then you will be able to stay in the efficiency sieve.

Mark and mail the attached coupon and learn how the I. C. S. can train you to stand the employer's test.

To send the coupon will place you under no obligation whatever; it will simply bring you the information you want. Send the Coupon NOW.

International Correspondence Schools
Box 939, SCRANTON, PA.

Please explain, without further obligation on my part, how I can qualify for a larger salary and advancement to the position, trade, or profession before which I have marked X.

Electrical Engineer	Machinist	Chemist
Electric Mach. Des.	Toolmaking	Assayer
Dynamo Foreman	Molding	Commer'l Illustrat'g
Electric Lighting	Blacksmithing	Bookkeeper
Electric Railways	Civil Engineer	Stenographer
Electrician	Stationary Engineer	Civil Service Exams.
Telephone Expert	Gas Engineer	Commercial Law
Concrete Construct'n	Refrigeration Eng.	Architecture
Mechanical Engineer	Sheet-Metal Drafts'n	Contracting & B'ld'g
Machine Designer	Marine Engineer	Advertising Man
Mechanical Drafts'n	Mining Engineer	Window Trimming
Patternmaking	Structural Engineer	Automobile Running

Name _____

St. & No. _____

City _____ *State* _____

Present Occupation _____